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WORLD RESOURCES OF ENERGY AND THEIR UTILIZATION

ONE of the proposals made by the United Nations Educational, Scientific and Cultural Organisation for bringing the nations together was that certain topics should be selected for world-wide discussion and study each year. For 1950, the year in which the Fourth World Power Conference has met in London, the topic suggested by Unesco was energy in the service of man, and that subject has also been taken as the main theme of the British Association's meeting in Birmingham. An exhibition illustrating this theme has been arranged by the National Coal Board, the British Gas Council and the British Electrical Authority in collaboration with the Birmingham Municipal Museum and the Common Good Fund, while a programme of films on scientific subjects which the British Universities Film Council is presenting will also include films illustrating man's use of energy. Particular aspects of the broad problem, such as civil applications of atomic energy, chemical energy, the gas turbine and agricultural engineering, are engaging the attention of the individual sections of the Association.

The presidential address by Sir Harold Hartley, on man's use of energy (see p. 368 of this issue), is thus both topical and introduces a main theme of the meeting. Fresh from his chairmanship of the World Power Conference and, less than a year earlier, from participation as a British Government delegate at the United Nations Conference at Lake Success on the Conservation and Utilization of Natural Resources, Sir Harold's masterly discourse provides an admirable background for the several discussions and even for other authoritative but specialized addresses like Sir John Cockcroft's Romanes Lecture on the development and future of nuclear energy. Sir Harold's address is, moreover, a most appropriate sequel to Sir John Russell's presidential address last year on world population and world food supplies, and in the sweep of its historical survey alone worthily commemorates the centenary of Clausius's formulation of the Second Law of Thermodynamics, governing the conversion of thermal energy into work useful to man.

It is, in fact, as Sir Harold points out, only a century since man first understood the full import of the word energy and its significance as the driving force of all physical and chemical change and of life itself; yet it has been man's use of energy that has shaped so largely the material progress of the human race. "The story of material progress is man's invention of tools to make his muscular work more effective or to store it and raise its potential, as with the bow and arrow, his invention of machines to multiply his force and ease his tasks, or to repeat them with accuracy independent of the hand or eye. Animals, wind or falling water gave him the energy he needed to multiply his effort. The successive metal ages, copper, bronze and iron, mark man's discoveries of new weapons and machines, and his inventive use of energy in fuels and furnaces to smelt their ores."

Although the birth of modern science in the seventeenth century yielded a fresh understanding of machines and quickened the tempo of invention, for more than two hundred years practice outran theory, in spite of all the great developments which Sir Harold passes in review. Only with the idea of energy and the recognition of its laws a century ago did we pass the great divide in engineering between the old and the new, and enter on what may be termed the age of power production. Starting from the theory of the steam engine, there came a gradual realization of the common driving force behind all physical and chemical changes, and of the laws of energy which govern them. In the hands of Helmholtz, Willard Gibbs, van 't Hoff, Planck and Gilbert Lewis, those laws have become a universal instrument of great power and economic importance in predicting what is possible.

The continuous expansion and the rapid changes in the technical and social pattern of the world in the following century, outlined by Sir Harold in a series of brilliant paragraphs, bring out both the scale of developments and the pace of scientific advance. Not merely were the rapid progress of electricity, of the internal combustion engine and of wireless creating profound changes in the social and technical pattern, but also discoveries like those of Becquerel, Röntgen, J. J. Thomson, Rutherford, Planck and Einstein changed profoundly man's understanding of Nature's processes and at the same time gave him new techniques and new tools for further rapid advance. Nor can the limits to such advance and development yet be predicted.

From this fascinating picture of development and of achievement in raising the standard of human health and comfort, as well as productivity, which Sir Harold unfolds, certain features emerge. First, there is the extent to which the increase in the production of energy has been accompanied by fresh demands for energy. What Sir Harold terms the Domestic Revolution—the scientific application of heat and power in the home—is one example; and the common experience of power 'cuts' in winter may well give point to the question he asks, how long can the world's resources meet these growing demands. Some of them, as in agriculture, have given a new impetus to food production and counterbalanced to some extent the drift of man-power from the land. The availability of energy has also made possible a new partnership between agriculture and industry in the processing of farm products. Canning, refrigeration and deep freezing, air-conditioned transport, crop drying, fermentation processes and the conversion of farm residues into useful products all represent not merely demands for energy, but also the impact of energy on the whole economy of society.

Energy, Sir Harold Hartley commented, is the multiplier of human effort. What has increasingly marked the last half-century, however, is a change in the character of production: human physical effort has been replaced by other powers as the working energy on which the world's production is based. That thesis was elaborated nearly two decades ago in Mr. F. Henderson's "The Economic Consequences of Power Production"; but even now his main point that modern power production embodies a profound and vital change in the relationship of human labour to the products and processes of the world's work is not generally appreciated. Had the significance of this change, and the consequence that human service associated with the machine ceased in its essential character to be labour in the old sense, been fully understood, much industrial friction and loss of production might have been avoided.

That human labour, in the sense in which Mr. Henderson wrote of it, has for the first time in human history ceased to be the measure of output, is a factor which has to be taken into account in considering the increase of productivity in industry and elsewhere. It has its bearings on incentives and problems of leisure as well as on technological unemployment. This is less prominent to-day than when Mr. Henderson wrote; but the maintenance of full employment requires close attention to the mobility of labour, with all its implications, which is here the central issue.

Into such social and economic issues Sir Harold Hartley did not enter; but they clearly cannot be avoided if mankind is to reap the full benefits in the way of leisure and greater abundance and higher standards of living which the increased supplies of energy and this second industrial revolution offer him. Nor can the secondary effects of the wider use of energy be disentangled from social and economic questions. The virtual annihilation of distance, the growing scale of operations and the increased use of power, as Dr. Ellice McDonald pointed out last October, are changing the face of research itself by bringing scientific workers closer together, providing them with ever more powerful instruments and increasing the need for team-work. Despite all the reversals in certain spheres of the past five years, the rapid interchange of persons and ideas has brought the world into a much more closely integrated unit. It has quickened the senses and nerve fibres of nations, and has given them a new awareness of events—a new world consciousness—which in due time must display more fully their inescapable community of interests. Some of the most outstanding achievements of the war years were the outcome of just such international interchange of ideas and persons.

The answer to the question how long the world's resources can meet these growing demands must depend to a large extent on social and economic factors, and that for other reasons than the one given by Mr. Henderson. Sir Harold Hartley, in seeking an answer to the question, notes two important factors. First, reviewing the world's resources of fuel and power, he directs attention to the most unequal distribution of resources between nations. Countries north of latitude 20°, for example, contain 94 per cent of the world's coal reserves and 83 per cent of the oil reserves, while those to the south contain two-thirds of the water-power potential. Energy resources, which must clearly determine the pattern of development of countries, are not the only factor which makes for such differentiation between countries. Deposits of phosphates and potash

required for agriculture, while adequate in total for centuries, are most unequally distributed. Reserves of metals, such as copper, zinc, lead and tin are estimated as adequate for some decades only, and here again the distribution of ore deposits emphasizes the inter-dependence of countries. The world sufficiency of energy reserves is, as Sir Harold observes, but a poor consolation for the countries that have few.

The unequal distribution of energy and material resources emphasizes the importance of international co-operation, which is itself conditioned by social and economic factors. Co-operation is the only alternative to international rivalry and tension, and little as Sir Harold says on this point, his experience at Lake Success last year has clearly convinced him of the possibility of effective international co-operation in the conservation and utilization of natural resources. In his Birmingham address he does no more than refer to the importance of transport of power in this connexion. The transmission of electric power over long distances by high-voltage direct current should permit the economic transmission of large blocks of energy for perhaps a thousand miles by underground or submarine cable, thus linking consuming centres with new and distant sources of hydro-electric power. Sir Harold referred also to the possibility of linking the British and European grids, and thus securing a better balance between capacity and requirements by taking advantage of the seasonal variations in capacity and the diversity of demand.

The second factor stressed by Sir Harold is that the major advances have been made in the energy industries. Most modern types of plant have reached a point where only fractional progress is likely to be made and where the limits may be the discovery of new alloys or the higher cost which the gain in efficiency would not justify. There are, it is true, some new developments such as the gas turbine, and limited possibilities in the use of wind power, tides and solar radiation. Discussions at the World Power Conference indicated that the difficulties to be overcome before the use of nuclear energy becomes economical are most formidable, and their solution will require intense effort over a long period. The first use of fissile elements may well be to transport energy to places far remote from other sources.

Accordingly, the world's increasing demands for heat and power are being met largely by improved efficiency and the elimination of waste. In Britain until 1938, the total fuel consumption had been almost unchanged for a quarter of a century; although the population increased by 10 per cent in that period, the use of heat and power in industry was extended and new industries arose. The additional energy required came from the same amount of fuel by increased efficiency of use. Nevertheless, the overall efficiency of use of heat and power in Britain is still probably less than 15 per cent, and there is urgent need for large economies to save the fuel that will be needed for increased production. Sir Harold himself sees in the adoption of automatic control and precision techniques large possibilities of saving in this respect, and in this connexion urges, like Mr. Henderson, that one of the indexes of economic progress should be not the energy used per worker, but the output of goods and services per horse power employed. He rests his hope for the future in part on this more efficient use of the resources of Nature, in part on man's new understanding of the processes of Nature, and in the growing recognition of the dependence of one nation on another.

There once again we are dependent on economic and social factors. Two years ago at Johannesburg, Sir Harold, surveying the limiting factors in world development and the particular contribution of the engineer and man of science, recognized that man is the ultimate limiting factor. So to-day, in this divided world, he suggests that the solution of our present problems of standards of living depends on whether men's minds are bent on the quest of plenty or on the quest of power. On that ultimately depends, for example, whether these resources in the way of transport, of fertilizers, irrigation, heat and power can be brought to meet the needs of the less-developed countries with their ill-nourished millions, with all the benefits which the more advanced countries would in turn reap from such development. Technical assistance to such countries, as Lord Bruce observed in his Messel Memorial Lecture at Newcastle upon Tyne, is primarily a matter of scientific, technical and administrative assistance—in other words, of trained man- and woman-power. It is a question of atmosphere—of the confidence in which co-operation and understanding can grow and men and women give of their best.

"On man's wise use of energy depends so much the future of this troubled world." It is not for us to command the deep wells of unconscious thought, whence wisdom, like creative genius, may issue. But out of the rich experience which has enabled Sir Harold to tell so fascinating a story of the development and use of energy by man, others may draw the inspiration and the resolve which also are needed if we are to match the resources science has put at our command with the opportunities and the needs lying before us.

STORY OF BIRMINGHAM

Birmingham and its Regional Setting

A Scientific Survey. Prepared for the Meeting held in Birmingham, 30th August–6th September 1950. (Published by the Local Executive Committee.) Pp. xix+334. (London: British Association, 1950.)

THE publication this year of the "Scientific Survey of Birmingham and its Regional Setting" follows the usual British Association practice of issuing to its members a scientific survey, prepared by the local committee, of the locality in which the annual meeting of the Association is taking place. This handsomely produced volume, with its wealth of charts and data, compares favourably with the high standard of previous surveys, and the Birmingham local committee is to be congratulated on a job well done.

The book is divided into the following four parts: physical background; evolution of settlement before 1700; the Industrial Revolution; and the modern regional and economic pattern. Within the parts the contents are further subdivided into sections, each of which is a water-tight article on a particular topic, written by an expert (or experts). The main criticism to be levelled against this method is that there is inevitably some overlapping and consequent repetition between the sections. The only other serious complaint which may be made against the Survey is that it has no index.

In the part of the book on the physical background —relief and physiographical regions, geology, geomorphology, climate, soils, vegetation and fauna—the geographical area is wide (rightly so) and includes a large part of the counties of Warwickshire, Staffordshire (South Staffs) and Worcestershire. The geography of Birmingham is not particularly striking; and, as is borne out by the early history of the place, its setting offers no strategic advantages and does not obviously warrant an important city. It is the geological wealth, coupled with the building up of industrial talent, which has made Birmingham the second largest city of England.

We learn that the area shows little trace of Celtic or the superimposed Roman culture, and, by the time the Domesday Book came to be written for the Norman Conqueror, the future great metropolis, the name of which is of Saxon derivation, was so unimportant as to be assessed at a mere four hides. Throughout the Middle Ages, Birmingham lay at the fringe and the intersection of the civil authority of three cities—Warwick, Worcester and Stafford. As a result of being approximately situated at the point where the three county boundaries met and by not suffering from lords of the manor or gilds and their restrictive practices, as did the more important towns and districts, Birmingham attracted craftsmen and merchants who pursued their activities in an atmosphere of almost complete freedom—"By the end of the Tudor period, therefore, we have a picture of Birmingham as a busy market and manufacturing town, already an important focus for much of the Plateau and places beyond, and enjoying a measure of political, social and economic freedom that was exceptional, if not unique in this part of the country". No doubt the modern 'Brummie' still possesses some of the character of his forefathers.

The natural assets of ironstone and wood for charcoal-burning led to the establishment of the individual iron-working craftsmen; but the district was also endowed with seams of Thick Coal that were easily mined on or near the ground-surface, though whether, on seeing the derelict land of the Black Country, this can be described as an asset, is a question for discussion. However, by the end of the seventeenth century, when coal had displaced charcoal, the population of Birmingham increased rapidly so that in a hundred years it achieved its position as the leading industrial city in England. From 1700 onwards the history of Birmingham is synonymous with the history of the steam engine and the successive developments in the ferrous industry. But the city also early developed a reputation for the manufacture of jewellery, toys, buttons and other trinkets, and this tradition is maintained to-day in the wealth of light industries that abound in the district. For, the uneconomical squandering and consequent exhaustion of the coal resources of the Black Country have left that nineteenth-century eyesore in a state where the smoke of the blast furnaces no longer belches forth; and, though coalfields have been developed in other districts round about, Birmingham can scarcely be said to be a centre of the heavy industries of Great Britain.

However, the unique engineering skill which evolved and accumulated in Birmingham and its satellite towns during the past few centuries has been passed down to the present generation, and the city in which Boulton and Watt first went into partnership and in which the short-lived Lunar Society shone so brilliantly is still maintaining the tradition by its multitudinous manufacturing industries, its technology and its University.

VITAMINS

Vitamin Methods

Edited by Dr. Paul György. Vol. 1. Pp. x+571. (New York: Academic Press, Inc., 1950.) 10 dollars.

Vitaminology

The Chemistry and Function of the Vitamins. By Dr. Walter H. Eddy. Pp. v+365. (Baltimore, Md.: Williams and Wilkins Co.; London: Baillière, Tindall and Cox, 1949.) 46*s*. 6*d*. net.

THE first of these two books, "Vitamin Methods", is a valuable work. Within its 571 pages will be found, gathered together for the first time, an exhaustive account of most of the better approved methods for estimating the twenty or thirty vitamins now known (and of their different forms, modifications, precursors, etc.). In each instance, full and explicit working directions have been provided, in order, as the editor says, "to spare the reader, as far as possible, the necessity of consulting other reference sources before a given assay method could be considered complete and workable".

Vol. 1 deals with physical, chemical and microbiological methods of determination, and Vol. 2, to follow later, will be devoted to biological assay. Nothing of this kind has hitherto been attempted, apart from the praiseworthy "Estimation of the Vitamins" ("Biological Symposia", 12; Lancaster, Pa., 1947), edited by the late W. J. Dann and by G. H. Satterfield, which is, however, a work on a definitely smaller scale; there is also the useful "Methods of Vitamin Assay" (New York, 1947), prepared and edited by the Association of Vitamin Chemists, Inc., which, however, confines itself to working directions for certain selected methods, and is in no sense a comprehensive treatise; and another valuable monograph, in French, is "Le Diagnostic Chimique des Avitaminoses, Techniques Actuelles" (Paris, 1942), by P. Meunier and Y. Raoul.

The plan of "Vitamin Methods" is unusual in one regard. Each author deals not with a particular vitamin, but with a particular technique, which he proceeds to discuss in its application to each of the vitamins in turn. Thus in the first 146 pages of the book, "Physical Methods of Vitamin Assay" are considered by E. T. Stiller, of the Wyeth Institute of Applied Biochemistry, Philadelphia, Pa. This portion, after a brief introductory section, describes one by one the methods involving ultra-violet absorption spectra, fluorimetric determinations and polarographic technique. There follows the section on "Chemical Methods of Assay", by P. György, of the School of Medicine, Philadelphia, Pa., and S. H.

Rubin, of Hoffmann–La Roche, Inc., New Jersey. This deals with colour reactions, fluorimetric tests, etc., in relation to twelve different vitamins or groups of vitamins (namely, A vitamins and carotene, D vitamins, E vitamins, K vitamins, vitamin B_1, nicotinamide, vitamin B_6, choline, inositol, *p*-aminobenzoic acid, folic acid, ascorbic acid).

The section on "Microbiological Methods", by O. A. Bessey, of the University of Illinois, begins with an adequate treatment of general principles, such as the collection of specimens, the measurement of small volumes, microcolorimetry and so on, and then describes the application of microchemical methods, not only to vitamins A and C, and riboflavin, but also to serum phosphatase, serum iron and serum protein. The account of microbiological methods is in the expert hands of E. E. Snell, of the University of Wisconsin. He divides his subject-matter into a description of the methods using (*a*) lactic acid bacteria, (*b*) yeast, (*c*) *Neurospora*, and (*d*) other micro-organisms. The book concludes with an excellent survey on the use of optical instruments in vitamin analysis from the pen of E. Hirschberg, of the Hoffmann–La Roche Nutrition Laboratories.

A difficulty facing the compilers of a book of methods in a subject developing so rapidly is to keep it sufficiently up to date. We can confidently expect that in later editions the editors will see to it that descriptions of some of the more obsolete techniques are abandoned in favour of more recent improvements. For example, for extracting carotene from plant tissues, grinding with acetone in the cold is to be preferred to digestion with alkali. Again, for the determination of vitamin A in blood, some allusion to Kimble's method is to be expected. For the measurement of vitamin E in tissues, reference to the newer developments in technique would no doubt be incorporated.

It will be observed that the authors comprise an all-American team. In this connexion, it is pleasing to record that the book is commendably free from national bias, and it nearly always gives credit where credit is due to fellow-investigators in other parts of the world. The authors, indeed, deserve to be complimented on the catholicity of their reading, on their historical perspective and on their balanced judgment. This is a welcome sign. Too often, in the United States, no less than in other countries, men of science have been tending to take the easier course of restricting their study of literature to the home market. The consequence sometimes has been that a method, originated by, shall we say, *R.* of Ruritania, and afterwards adopted, or adapted, by—let us call him—*U.* of Urbania, becomes known, before long, in the latter country as *U.*'s method. Such national exclusiveness in science is not a new phenomenon, nor limited to any country. A century and a half ago, Napoleon Bonaparte, who had made some study of the contemporary scientific scene, wrote, "I have been told that the English were accomplishing great things in Chemistry. . . . I assert, nevertheless, that the French possess ten times, and perhaps a hundred times, as much chemical knowledge as the English"[1]. Returning to the current scientific world, it is all the more refreshing to find a book so commendably free from this defect of national insularity.

There are a very full bibliography and author and subject indexes. The planning of the book and its format are both excellent.

Dr. W. H. Eddy's book, "Vitaminology: the Chemistry and Function of the Vitamins", will prove useful to a rather more limited audience, and in particular to the more highly specialized research worker. It is concerned especially with some of the biochemical aspects of recent vitamin research, and contains little detailed information about such matters as the pathology and the clinical effects of the vitamin deficiencies.

On the whole, the book can be regarded more as a useful compilation than as a critical study, and indeed the knowledgeable reader will find places where statements are quoted from the literature without comment, which have since been controverted or have failed to win acceptance.

A commendable feature is the large number of structural formulæ included. Unfortunately, however, many errors have crept in; and in a somewhat cursory preliminary inspection, I noted printers' errors, inaccuracies or inconsistencies in no fewer than thirteen of these formulæ (α-carotene, co-carboxylase, co-enzyme I, co-enzyme II, alloxazine, *iso*-alloxazine, indole-3-acetic acid, *p*-aminobenzoic acid, phytin, α-tocopherol, chroman, vitamin K, folic acid).

This work cannot claim to be a general text-book. Perhaps for this reason there is an entire absence of pictures, diagrams or illustrative curves. Much of the information which it contains is given in the form of a succession of summaries of—or, sometimes, quotations from—the original papers. This feature will make the volume useful as a source book to the advanced investigator, when he has occasion to conduct a search of the literature.

The references quoted are given in numerical order, section by section, and not according to the Harvard (so-called) system now generally used by biochemists; nor are the usual international conventions adopted in citing and abbreviating the names of the journals. There is no author index, and the subject index is not very full.

LESLIE J. HARRIS

[1] Kircheisen, F. M., "Memoirs of Napoleon I", 243; translated by F. Collins. (London: Hutchinson and Co., 1928.)

BORDERLAND OF CHEMISTRY AND BIOLOGY

Chemical Constitution and Biological Activity

By Dr. W. A. Sexton. (Industrial Chemistry Series.) Pp. xxi+412. (London: E. and F. N. Spon, Ltd., 1949.) 55*s*. net.

THIS volume, to which Prof. A. R. Todd contributes a foreword, can best be described as consisting of a series of essays reviewing modern advances in our knowledge concerning the manner in which chemical substances can modify the functions of living organisms. While the book is directed primarily to chemical readers, the author expresses the hope "that it may have a wider appeal, and that those biologists who have an appreciation of structural organic chemistry may find in it material which will stimulate their interest and emphasize the enormous contributions which chemistry is now making towards the advancement of biological knowledge".

The first part of the book consists of an introduction, together with five chapters covering general topics,

such as macromolecules, chemical mechanisms determining drug activity, physico-chemical considerations, the modification of drugs by living organisms, and the effect of specific chemical groups; and the second part, consisting of sixteen chapters, covers a wide range of selected topics, such as growth factors and their antagonists (five chapters), porphyrins, choline and its derivatives, quinones, symbiosis and parasitism, antibiotics, some aspects of hormones, chemotherapeutic agents and insecticides (three chapters), cancer, plant growth regulators, and immunology. While many of these topics could, as some have already done, form the subjects of lengthy monographs, the author has attempted to embrace them all in a volume of less than four hundred text pages. The effect is that some of the chapters are admirable short surveys which do justice to the subject-matter, whereas others are too briefly kaleidoscopic. To compensate for the inevitable compression, Dr. Sexton has made good use of tables, nearly sixty in all, for the concise presentation of data; and at the end of each chapter he has given excellent lists of leading references, these, in themselves a mine of information, being a most valuable feature of the work.

The two chapters dealing with pyridoxin, pantothenic acid, biotin, pyrimidines, purines, and pterins are excellent reviews, but it is indicative of the rate of progress that folic acid antagonists are scarcely mentioned. The chapter on plant growth regulators, to which Dr. Sexton's own researches have contributed notably, is a valuable review of a widely scattered literature, but the oat coleoptile test might have been described with greater accuracy.

Although written in a very readable manner, the work is marred by a considerable number of errors that should not have appeared in a book, which is not really a long one, costing as much as this one does. In the table of natural α-amino-acids, which is "given for reference purposes", the formulæ for thyroxine and threonine are given wrongly. These are not the only erroneous structural formulæ, which is to be regretted since a book of this kind giving a wealth of structural formulæ for many substances of topical interest is likely to be used for reference purposes in such matters. The following are given incorrect structural formulæ: eserine, tubocurarine, myanesin, endochin, benzoylglycuronic acid, phenylglycuronic acid, polyglutamic acid, and poly-N-acetylglucosamine, while the chemistry given for muscarine, formulated as the aldehyde corresponding to choline, was discredited many years ago. There is evidence also of lack of care in the rendering of scientific terms: thus, strepogenin appears repeatedly as streptogenin, and adrenochrome as adenochrome; dibromosalicil appears as dibromosalicin, quite another matter, and the anthrax bacillus appears twice as *Bacillus anthris* and once, correctly, as *Bacillus anthracis*; *P. cathemerium* appears as *P. cathemarium*, and a table of covalent radii is given under the heading of bond-lengths. Although the Chemical Society had misgivings about the term 'radicle' in 1905 and took another twenty years to replace it by 'radical', the obsolete rendering is consistently used in this book. The unfortunate impressions are given that riboflavin, rather than mepacrine, has antibacterial and antimalarial properties (p. 93), that aspirin will protect animals against the physiological effects of administered thyroglobulin or thyroxine (p. 387), and that the antiserum to a synthetic antigen derived from cellobiuronic acid, while precipitating the capsular polysaccharide of pneumococcus type III when the latter was combined with a heterologous protein, also "precipitated *antisera* to pneumococci types II, III and VIII" (p. 385).

The timeliness of a book of this nature will be readily conceded; but it is to be regretted that a much-needed volume should contain numerous minor inaccuracies. Apart from the somewhat inelegant rendering of the porphyrin structural formulæ, the standard of printing is high, and the volume is attractively bound.

J. WALKER

VISUAL AIDS IN SCIENCE TEACHING

Visual Aids

Their Construction and Use. By Gilbert G. Weaver and Prof. Elroy W. Bollinger. Pp. vii+388. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1949.) 36*s*. net.

THIS book is superior in most respects to the large and well-bound volumes on visual aids to teaching, particularly to the teaching of technology, which appear at fairly frequent intervals in the United States. At the price of 36*s*. it must be regarded as expensive for a work of less than four hundred pages, many of which only deal with the problem from the American point of view.

The really useful part of the book discusses in a thorough though sometimes rather obvious manner the older direct and the newer optical projection methods of presenting material to students of the commoner technologies. Strangely, the authors seem to handle the methods which employ blackboards, display cases, posters and pictures with more conviction than they evince with the cinema and other optical devices. Perhaps this is all to the good, for the glamour of elaborate optical aids has tended to obscure their real purpose: they should be regarded as useful teaching tools and nothing more.

One of the main shortcomings in works of this kind is that they fail to stress sufficiently that the film, picture, model or diagram is in itself no cure for verbalism, even though each is thoroughly understood so far as its spatial, colour and temporal relationships are concerned. In the work under review, some space has been devoted to this important matter. The plain fact is that the scientific worker and technologist, in common with others, need languages to express their ideas and as vehicles of creative thought. It is necessary to spot the most convenient languages for the task in hand, whether these are verbal, symbolical or pictorial. This is true of both the research worker and the teacher. Further, there must be facility in translating from one language to another, and this is exactly where there is a failure to meet the needs of basic thought and teaching in science. The cure for verbalism is not the equally vicious complaint of pictorialism nor, in extreme cases, eidetism; and in this connexion it is necessary to assess more critically the real educational value of many 'visual aids'.

It remains to be said that in spite of the very worthy production of the book, the half-tone illustrations with which it is illustrated have neither the size nor the quality desirable in a work of this type. Books on visual aids should set a good example.

W. L. SUMNER

British Inventions

By Dr. F. Sherwood Taylor. (British Life and Thought Series: Published for the British Council.) Pp. 44+16 plates. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1950.) 1*s.* net.

It is a tribute to the author's judgment and ease of expression that so much has been compressed into such a readable compass. The result is far more than a mere catalogue of British inventions; Dr. F. Sherwood Taylor traces their origins in the needs and background of contemporary life. For example, Britain's obvious dependence on the sea is reflected in the multitude of marine inventions.

The sequence that the author has adopted contributes to an understanding of the development of invention and its relation to scientific discovery. After an introduction, with special reference to Francis Bacon, there follow sections on scientific instruments, textile machinery, machines to make machines, and the steam engine. The latter part of the book explains the rise of modern engineering and the distribution of power and has a special section on chemical manufactures.

This welcome additional volume to the British Council's series on "British Life and Thought" concludes with a survey of instruments in the nineteenth century and of British invention in modern times. Among the numerous excellent plates, there are three photographs—of the late Lord Rutherford, Sir Robert Watson-Watt and Air-Commodore Sir Frank Whittle—a happy reminder of the contributions that Great Britain has made to fundamental research of world-wide significance.

Differential Algebra

By Prof. Joseph Fels Ritt. (American Mathematical Society: Colloquium Publications, Vol. 33.) Pp. viii+184. (New York: American Mathematical Society, 1950.) 4.40 dollars.

In 1932 the author published "Differential Equations from the Algebraic Standpoint" (reprinted in 1948), which dealt with differential polynomials and algebraic differential manifolds. Since 1932 much progress has been made, so the author has prepared a new exposition, to which he has given the title of "Differential Algebra", which emphasizes that it deals with the three operations of addition, multiplication and differentiation. The problems dealt with are really closely allied to those of the usual theory of differential equations, but they are disguised by the abstract nature of the treatment. This treatment has been adopted so as to separate algebraic from analytical methods; but at times it seems rather unnatural, and the book is not easy reading.

Statistics

An Intermediate Text Book. By Dr. N. L. Johnson and H. Tetley. (Published for the Institute of Actuaries and the Faculty of Actuaries.) Vol. 1. Pp. xii+294. (Cambridge: At the University Press, 1949.) 20*s.* net.

The primary purpose of this book is to satisfy the needs of actuarial students studying for the examinations of the new syllabus of the Institute of Actuaries; the first section of this syllabus is covered in this volume, and the second section is to be dealt with in the companion volume. The first four chapters introduce the student to the subject-matter of statistics and to the methods of handling data by means of diagrams, moments and correlation techniques. A section on statistical inference introduces three chapters on probability, and the last two chapters are on large-sample statistical tests.

The text is well written, and, in particular, the notion of a statistical test is made very clear, though perhaps estimation is too briefly discussed. The exercises are, in general, too difficult, even when some hints and answers are given. The actuarial student will probably be well served by this book. It is difficult to say how well other classes will appreciate the book until we see the second volume. At the moment, the omission of small-sample theory and the preoccupation with some matters make the work less interesting than it might have been.

D. V. Lindley

Birds of the Coast

Written and Illustrated by C. A. Gibson-Hill. Pp. xxxii+216+16 plates. (London: H. F. and G. Witherby, Ltd., 1949.) 10*s.* 6*d.* net.

This volume follows the large handsome pictorial introductory volume, "British Sea Birds", by the same author and publisher; but it is pocket size and contains more reading matter. Even so, it is difficult to compress into two hundred small pages such a considerable and potentially intractable subject, since in Great Britain, a land of coasts and islands, almost every bird could pass the author's somewhat ambiguous test of what constitutes a coastal species. The author would have made a more useful contribution had he disciplined himself to describing the essentially littoral species, and giving more information about these, instead of introducing rare and inland-breeding species (for example, cream-coloured courser, pratincole, stone-curlew) and many others which only visit the shore occasionally in winter. There are several omissions from the distributional maps. The photographs are excellent, and the author's clear diagrammatic sketches of plumage markings are most useful. This work can be recommended as a pocket-size introduction to the birds seen on a seaside holiday.

Bees, Flowers and Fruit

The Story of Insect–Plant Relations. Written and Illustrated by Herbert Mace. Pp. 184. (Harlow: Beekeeping Annual Office, 1949.) 8*s.* 6*d.* net.

The author of this book, who is a well-known beekeeper and writer on apicultural subjects, has had a life-long interest in bee plants. His present work is written on popular lines, and the greater part is devoted to flowers and pollination with special reference to the role of the hive bee. Mr. H. Mace has drawn freely from Knuth's monumental and comprehensive work, "A Handbook of Flower Pollination", as he readily admits. As Knuth's work, in three large volumes, is not likely to be available to most beekeepers or amateur naturalists, Mr. Mace's book should fulfil a useful purpose in rendering at least some of the information more generally available. The chapters on bee pasturage, embodying many of the author's own observations, are among the more useful features of the book.

Some may feel that the title is somewhat misleading, for there is but little information on bees themselves and very little on fruit. Under the latter category notes are given on the nature of the flowers of tree, bush or berry fruits, their degree of attractiveness to the hive bee and their times of flowering. It seems unnecessary to have attempted to include cultural notes in a work of this kind.

MAN'S USE OF ENERGY*

By Sir HAROLD HARTLEY, K.C.V.O., C.B.E., M.C., F.R.S.
President of the British Association

FOR the sixth time the British Association is enjoying the hospitality of Birmingham, this great centre of industry and learning. It is a happy coincidence and a special pleasure to all that the Association is meeting in Birmingham in the jubilee year of its University. May I offer to the Vice-Chancellor on behalf of the Association our warmest congratulations and good wishes. Although the University of Birmingham is young, as universities go, it inherits the traditions of learning and culture that have flourished in Birmingham ever since the days of that brilliant galaxy of talent—Darwin, Galton, Boulton, Watt, Priestley and their friends—the Lunar Society. If we needed any reminder of the great part that Birmingham played in the Industrial Revolution, we have it in that admirable "Scientific Survey" for which all are most grateful to the authors. It was in Birmingham that the genius of James Watt found at long last the means and opportunity to complete his engine, that decisive step in the history of industrial progress.

What better setting could there be for the subject of my presidential address: "Man's Use of Energy". It seemed to me the natural sequel to Sir John Russell's address to the Association last year, and a fitting remembrance of the centenary of that landmark in the history of science, the Second Law of Thermodynamics, the law that governs the conversion of thermal energy to work of use to man.

It is only a century since man first understood the full import of the word energy and its significance as the driving force of all physical and chemical change and of life itself—what Clerk Maxwell called "the go of things"; and yet it has been man's use of energy that shaped so largely the material progress of the human race. Among the milestones of that early progress are the discovery of fire, the raising of crops, the invention of tools, weapons, the wheel and machines, the copper, bronze and iron ages, and the use of animals, wind and water as sources of power.

Throughout the ages the dependence of the human body on food and warmth, and the demands of man for energy, have helped so much to shape the course of history. Even in this machine age of civilization, with the huge demands of industry and transport for heat and power, in Great Britain at least one-third of the energy consumed goes to satisfy our personal needs of heat and warmth and food; and so, man's own needs, the energy by which life is sustained, will be the starting point of this address.

Energy and the Human Body

Why does the body need this energy? Just as a ball of celluloid poised on a jet of water from a fountain will keep its place and spin so long as energy is there, so life depends upon that flow of energy. Even in sleep the muscles of the heart and lungs must maintain the circulation of aerated blood to meet the body's need of energy through the chemical reactions on which the steady state of living matter rests. We know from radioactive atoms, by which the movements of matter can be traced, that all parts of the body, even the bones, are being constantly renewed.

Then there are the muscles, on the movements of which life in turn depends. The intimate mechanism by which they derive their energy, their power to work, by chemical reactions from the intake of food and oxygen, is still one of Nature's secrets. It is a mechanism much more subtle than the internal combustion engine, as it works at constant temperature. The outstanding fact about the human body is that all its manifold changes and adjustments, thanks to Nature's catalysts, take place at the steady temperature at which evolution has decided that the body should work.

Comfort and life itself depend on that constant body temperature. Clothing, domestic heating and air conditioning are all designed to meet the body's thermal needs in its environment. The body mechanism can respond to a demand for greater heat production or its dissipation, but the demands on it are least in temperate climates with no extremes of heat or cold. Markham, following this clue in his book "Climate and the Energy of Nations", points out that the earliest civilizations were in the warm fertile regions of the Middle East and Southern Mediterranean. As the art of living improved with housing and domestic heating, dominance passed to the temperate climates, where it has since remained. Birmingham, I am glad to say, falls within Markham's zone of optimum conditions for man's creativeness.

But let us return for a moment to the destination of the energy consumed by the body when asleep. If fatigue is of the nature of some disturbance of the steady state, some of the energy may go to readjustment, to Nature's running repairs. It is significant that no less than a quarter of the intake goes to the brain, even when the organs of external sensation are at rest. It seems an enormous consumption for its weight, but it is maintaining the active state of the ten thousand million nerve cells of which the brain is composed. We speak of grey matter or the lack of it, and the grey matter consumes two to four times the energy needed by the white.

Why does the brain need this great expenditure of energy? Probably because it is the integrating unit, the control room, on which depends the marvellous efficiency of the body, the accurate co-ordination of sense and action; and the memory, that vast storehouse of impressions, must be kept alive like the automatic memories of the electronic calculators, but with an immeasurably greater efficiency. Even in sleep the subconscious mind is working with the flow of energy, and who can say how much we owe to it? In our researches we can plan our measurements and observations, accumulate new facts, but the flash

* From the Presidential Address delivered at Birmingham on August 30.

of inspiration that marks the great advances comes from the "deep wells of unconscious cerebration"; it is not at our command.

Life is dynamic, and the slender thread on which it hangs is that ceaseless flow of energy.

I must not dwell longer on these fascinating unsolved problems of the power engineering of the body and the human brain, or the mechanisms by which energy performs its tasks. Gilbert Lewis once asked if living things "were cheats in the game of entropy?" Does Nature even here obey her laws of energy? This we may never know for certain, but the presumption is—she does.

Man's Progress in the Art of Living

Man's progress in the art of living, the environment he has created for himself with its ever-increasing call for energy, is the product of the human brain. Its curiosity, its creative ingenuity, its ability to observe and take advantage of the unexpected, reflect its gradual evolution through man's efforts to improve his lot.

For a million years man was "the servant of untamed Nature", and only when he learned to tame her to his needs, to kindle fires and grow his food, did the social evolution, that made us what we are, begin. "Man", said Carlyle, "is a Tool-using animal. Weak in himself and of small stature, he stands on a basis, at most of the flattest-soled, of some half square foot, insecurely enough. . . . Three quintals are a crushing load for him: the steer of the field tosses him aloft like a waste rag. Nevertheless he can use Tools, can devise Tools . . . without Tools he is nothing, with Tools he is all!"

The story of material progress is man's invention of tools to make his muscular work more effective, or to store it and raise its potential as with the bow and arrow, his invention of machines to multiply his force and ease his tasks, or to repeat them with accuracy independent of the hand or eye. Animals, wind or falling water gave him the energy he needed to multiply his effort. The successive metal ages—copper, bronze and iron—mark man's discoveries of new materials from which to make his weapons and machines, and his inventive use of energy in fuels and furnaces to smelt their ores.

The Industrial Revolution

Even in those far-off days the name of engineer reminds us of the impetus that came in use of energy when man's mind was focused on the military art. Nevertheless progress was slow, with little help but trial and error save for a brief period among the Greeks, until the new freedom of the mind that came with the Renaissance and its spirit of inquiry taught man to question Nature by experiment and to read her answer. That was the birth of modern science. In his "New Atlantis", Francis Bacon made a prophetic forecast of the spirit and the optimism of the Scientific Age—"The end of our foundation", he said, "is the knowledge of causes and of the secret of things, and the enlarging of the bounds of human empire to the effecting of all things possible". At the same moment the experimental study of mechanics by Galileo was yielding a fresh understanding of machines and quickening the tempo of invention. In Great Britain, with the impetus that social freedom gave to industry, with the momentum of the Elizabethan age, and with our native genius, the times were ripe for change. It was in Britain that the machine age, the Industrial Revolution, with its dependence on energy, began. It was a great century of British invention. In textiles, Kay's flying shuttle, Hargreaves's jenny, Arkwright's frame and Crompton's mule led the world. Darby's discovery of smelting iron with coke instead of charcoal and Cort's reverberatory furnace and rolling mill for making wrought iron brought the blast furnaces and forges northwards to the coalfields from the woodlands of the South. Not all the improvements in machinery came from the users and makers of machines, but "some", as that shrewd old observer Adam Smith records, "by the ingenuity of those who are called philosophers or men of speculation, whose trade it is not to do anything, but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects". So science played its part.

It was a time of rapid growth, and with the advent of the factory and machines, supplies of power from water-wheels and animals were soon the limiting factor. For fifty years Newcomen's atmospheric engine had been the only means of draining mines as they went deeper to meet the growing needs of coal and iron, and no improvements had been made in its efficiency of one half of one per cent.

Watt's Steam Engine

Then in 1764, by one of those chances that make history, a model of Newcomen's engine went to a young Glasgow instrument-maker to be repaired. It stirred in the mind of James Watt a restless urge of his inventive genius and his intuition for mechanical design. Watt was not satisfied; he saw the waste of steam and instinctively he attacked the problem by the scientific method, by measurement. He measured the boiling point of water at different pressures, and the volume of steam formed from a volume of water; he made a model to show the quantity of steam used at every stroke of the cylinder. He was puzzled to find that steam could heat six times its weight of water from room temperature to boiling point, which Black explained to him by his discovery of latent heat. It was not until the following May that, in a flash of imagination on a walk, Watt saw that the waste of heat could be avoided by condensing the steam in a separate vessel, the condenser of the modern power unit. As he said, "I had not walked farther than the Golf House when the whole thing was arranged in my mind!" A hastily made model, of which a thimble, presumably his wife's, was part, satisfied him that he was right; but it was ten years before, in Birmingham, the first engine was made to his design, marking the birth of a new age of civilization.

Watt had now to earn his living as a surveyor, and, despite the help of friends and his partner Roebuck, the engine made slow progress. In 1768 he rode to London, took out a patent, and on his way north he went to Birmingham. There Matthew Boulton, with the ambition, the enthusiasm and the vision of a great industrial venturer, had just built the Soho works, the prototype of a modern factory. Watt saw there the opportunity to build his engine, while Boulton's quick eye saw the engine meeting the needs of industry for power. Watt's partner offered Boulton a licence to build engines for the Midlands; but Boulton's mind was moving on a grander scale, and his answer reveals the wide sweep of his imagination. "It would not be worth my

while", he said, "to make for three counties only, but I find it very well worth my while to make for all the world". So for six years Boulton waited until Roebuck's bankruptcy gave him the opportunity he sought, and then Watt came to Birmingham as his partner with his engine still unfinished. Within a year the first two engines were erected, the first at Bloomfield Colliery in Staffordshire, and the next at John Wilkinson's new foundry at Broseley to raise the water to drive the blast. Their success owed much to Boulton's encouragement and help and to the accurate cylinders made by Wilkinson's new machine tool with a limit of error not exceeding "the thickness of a thin sixpence" in a diameter of 72 inches.

The immediate market for the Watt engine was to drive the pumps in the Cornish mines with an efficiency four times that of the Newcomen engine. Watt went himself to erect them until another Scottish inventor, William Murdock, walked from Glasgow to Birmingham following Watt's footsteps. Watt was in Cornwall, and the interview with Boulton was not going well when Murdock's hat fell on the floor. Boulton noticed the noise. "What's it made of?" he asked. "Timmer, Sir," said Murdock, "I turned it myself on a bit lathey of my own making". Boulton recognized the skill and knowledge that had gone into the making of a lathe that could turn an oval, and it was not long before Murdock was building Watt's engines in Cornwall and settling arguments with the miners with his fists. It was there that he invented the first gas lighting for his home in Redruth and built the first model of a steam-driven carriage, that the vicar on a dark night mistook for the devil himself. While Murdock was erecting the engines, Watt was back in Birmingham busy with successive improvements to add to those he had already made —the tubular condenser, the steam-jacketed cylinder, the double-acting piston, expansive working, parallel motion, the governor, and the indicator to measure the work done in terms of horse power, Watt's unit that we still use to-day.

'Invention is the mother of necessity', and Boulton realized that the machines that were being invented in quick succession needed rotative power to drive them. "The people in London, Manchester and Birmingham are steam mad", he wrote to Watt, urging on him the need to take out a patent for "methods of producing rotative motion from the fire engine". Watt's cautious nature was intent on the success of his Cornish engines, and Boulton persuaded Murdock not to go to London to patent his steam carriage lest it should divert his energies. The first rotative engine was built in 1782 with Murdock's sun-and-planet gear. It was an immediate success, and by 1800 some five hundred engines in all had been built by Watt and Boulton, with a total output of 7,500 h.p., making together a twentieth of the output of a 100-megawatt generator of to-day.

Murdock's invention of gas lighting, like his steam carriage, was never patented. Soho was the first factory to be lit by gas, and it was illuminated by gas to celebrate the Treaty of Amiens in 1802. The gas-making plants made in Soho were being installed in textile works when Albert Winsor came to London with a scheme for distributing gas to private houses and for street lighting, the first plan for the distribution of energy. The absence of a patent weakened Murdock's opposition to the monopoly Winsor sought, and in 1812 the Gas Light and Coke Co. got its charter; but the gas engineer who made it a success was Samuel Clegg, who had been trained by Murdock at Soho. So Birmingham is the first home of the gas industry as well as of the steam engine.

1800–1850

Watt's patent ended in 1800, and the field was open to Trevithick's high-pressure engine with its greater efficiency. Progress at first was slow; even in Birmingham by 1820 there were only sixty engines with a "total steam-power in horses" of 1,000. But in the coal mines and the blast furnaces, steam power was indispensable to the production which was soon to make Britain the "workshop of the world". Sadi Carnot saw this so clearly in his classic essay on "The Motive Power of Heat". "To rob Britain of her steam engines", he wrote in 1824, "would be to rob her of her coal and iron, to deprive her of the sources of her wealth, to ruin her prosperity, to annihilate that colossal power".

In the cotton mills and steamships also, steam power was forging ahead. Fulton's *Clermont* with her Soho engine was the prototype in 1807 of the steamboats which were to open up America long before the railroad. But it was the triumph of Stephenson's *Rocket* in 1829 that heralded the new era, the harnessing of energy to production and transport on a scale that made possible the great expansion of the nineteenth century. In the factories steam-driven machines increased continuously the productivity of labour, and the rapid growth of the metal and chemical industries was dependent on supplies of heat and power. The steamship routes and the railways—the new arteries of commerce—quickened the flow of goods and men, and made accessible the raw materials of virgin lands and their new markets for industry. In the economic histories of these times, there are statistics of every kind, except the growth of horse power, without which that great expansion of human effort could not have been; but coal, the source of heat and power, is an index of development. In 1700 the output of coal in Britain was 3 million tons, or half a ton per head of population, and in 1800 it was twice as much per head; but by 1850, 60 million tons were being used, or three tons per head. In these years of rapid growth, practice, as so often happens, outran theory. There was no theory of the conversion of heat to work. It was an empiric age, when even Thomas Tredgold described the calculus as a device "for forcing the assent rather than by convincing the judgment". Until 1850, as L. J. Henderson used to put it, "The steam engine did more for science, than science did for the steam engine". But then, a century ago, came swiftly the idea of energy and the recognition of its laws, that great divide in engineering between the old and new.

The Laws of Energy

Carnot, a young French engineer, realizing the importance of a clearer understanding of the working of the steam engine and its complexity, simplified the problem by his conception of an ideal engine working in a reversible cycle. His stroke of genius in recognizing that the efficiency of his ideal engine must be independent of the working substance was the first step towards a general theory of energetics. He was the first to show that the efficiency of a heat engine depends on the temperature drop between the cylinder and the condenser. His forecast of the internal combustion engine reveals his clear grasp of

the engineering principles that are involved. If he had not died in 1832, his notebooks show that he would have anticipated much that came after him. As it was, his ideas had to wait a quarter of a century for recognition.

Next came Mayer, a young German medical man, who noticed when he bled his crew for fever on their arrival in the East Indies that their blood was redder than it would have been at home. He decided rightly that this was due to the reduced demand for heat to maintain the body temperature in the tropics. This set him thinking on the whole problem of the causal relationship of what he called the imponderables—work, heat and electricity—and led him to the theory of the interconversion but indestructibility of these various forms of energy. Once, when he was asked how he became involved in this problem, he replied, "Engaged during a sea voyage almost exclusively with the study of physiology, I discovered the new theory for the sufficient reason that I vividly felt the need for it". He calculated in 1842 the amount of work equivalent to a unit of heat and pointed out the inefficiency of the best steam engines of his day.

In 1847 Helmholtz, then a young army surgeon, from his study of metabolism, animal heat and muscular work was led along the same path as Mayer to consider what the relations must be between the different forces of Nature—heat, electricity, magnetism and chemical affinity—if perpetual motion is impossible. From a masterly analysis he reached the conclusion that "Nature as a whole possesses a store of energy which cannot in any wise be added to or subtracted from : the quantity of energy in inorganic nature is as eternal and unalterable as the quantity of matter". The effect of this new principle of the Conservation of Energy, the First Law of Thermodynamics, was to divert physical research into an entirely new channel. "Its object", said Hertz, "was henceforward to refer all phenomena in the last resort to the laws which govern the transformation of energy".

Meanwhile, Joule was attacking the same problem in Manchester by measuring the relation of work to heat in a series of researches which for insight, ingenuity and accuracy, with the means at his disposal, are unsurpassed. Joule was a faithful member of the British Association, which gave him scant encouragement. At seven successive meetings he read papers without any record of discussions. In 1843 his paper on "The Mechanical Value of Heat" was read to a chilly audience of six. At Cambridge, two years later, his paper on the measurement of the heat developed by rotating paddle-wheels in water excited no interest ; but at last at Oxford in 1847 William Thomson, fresh from helping Regnault with the first 'steam tables', and from reading Carnot's essay, saw the importance of Joule's paper on "The Mechanical Equivalent of Heat", though he was sceptical of Joule's interpretation. Their meeting led to one of those fruitful friendships and partnerships which the British Association has done so much to foster. Looking back, too, at the conservatism of a century ago and at the personal bitterness and opposition to new ideas that sometimes it engendered, I like to think that in this respect, at any rate, we can claim progress in the more sympathetic and interested hearing that new ideas receive both in the Association and in the world outside.

Even in 1849 Thomson had not shaken off the eighteenth-century idea of heat as something invariable in quantity like matter, thus showing how novel was the new idea of energy. So it was left to Clausius, a young German physicist, in 1850 to reconcile Carnot's theory of the heat engine with the newly discovered equivalence of heat and work and to formulate the Second Law of Thermodynamics in the general statement "that heat cannot of itself pass from a colder to a hotter body".

Rankine, a brilliant Scottish engineer, reached the same conclusion from his theory that heat is due to the rotation of molecular vortices. He had the conception of the thermodynamic function which Clausius later called 'entropy'. Rankine's analysis of the energy changes during the expansive working of the steam engine was later known as the Rankine Cycle and became the basis of design of steam prime movers.

Then Thomson recanted, and, having seen the light, with a bold sweep of imagination he surveyed all the sources of energy available to man for the production of mechanical work and recognized the universal tendency in Nature to the dissipation of energy. From it he drew the conclusion, momentous as it then seemed, that the earth must in time become too cold for human life. Our astronomers may give us a very different answer to-day.

So, starting from the theory of the steam engine, as the word thermodynamics reminds us, there came a gradual realization of the common driving force behind all physical and chemical changes, and of the laws of energy which govern them. Those laws, independent of hypotheses as to the nature of matter or of process, in the hands of Helmholtz, Willard Gibbs, van't Hoff, Planck and Gilbert Lewis, have become a universal instrument of great power and great economy in predicting what is possible. The height of a blast furnace was once doubled at great cost to see if the reducing power of its gases could be increased. Thermodynamics could have given the negative answer on a sheet of notepaper.

By 1850 industrialization and the use of power was spreading from Britain to other countries with great demands for energy. Between 1850 and 1900 the world's coal consumption increased from 100 to 1,000 million tons a year, and the route mileage of the world's railways grew from 25,000 to 600,000 miles. It was a time of rapid change, when the modern interplay of science and technology was taking shape and invention followed quickly on necessity. The steam engine made great progress in efficiency and size to meet the growing need of power. Double, treble and quadruple expansions followed one another to get the maximum amount of useful work from the higher-pressure boilers. Designers were slow at first to profit by the new theory, and improvements came mainly from details of mechanical design.

1850–1900

Two new ventures in the field of energy were destined soon to change the technical and social pattern of the world as steam had done a hundred years before. Since Murdock's day the gas and hot-air engines had been a favourable field for inventors, until with the work of Lenoir, Rocha and Otto the gas engine became a practical reality in the 'seventies, and the supply of town's gas made it a convenient source of small-scale power. Carnot's cycle gave it promise of greater efficiency than steam, and scientific enthusiasm was on its side. At the jubilee meeting of the British Association at York in 1881, Sir

Frederick Bramwell, speaking of the transmission of power by gas, predicted that in fifty years the steam engine might be spoken of as a curiosity to be found in a museum! Prophecies to the Association that are a challenge to the technician are apt to be belied, and it was only three years before Parsons's turbine rescued steam from its predicted fate. However, Bramwell's optimism about the gas engine was justified, though not as he foresaw. In larger units its promise of success was not fulfilled, but its progeny, the petrol engine and the diesel, are to-day in aggregate the greatest power producers in the world. The sinking of the first oil well in Pittsburg in 1859 saw the birth of a great industry, a new source of energy, which in the hands of Diesel and Daimler and many other eager spirits has given us the internal combustion engine of to-day with its far-reaching uses.

Even such an optimist about the gas engine as Fleeming Jenkin soon saw a cloud on the horizon. In 1882 he wrote to Ewing, "The gas engine goes slowly, its nose is put out of joint by this electrical affair". For the beginning of that "electrical affair" we must go back to 1831. Faraday, with his instinctive belief in the essential unity of the forces of Nature, was convinced that electricity could be obtained from magnetism as magnetism had been obtained from electricity. Time and again he experimented without result, until on August 29, 1831, the induced current was detected. Ten days of decisive experiment culminated in his paper on "The Induction of Electric Currents" which was to shape the future of electrical science and electrical industry. The discovery of electromagnetic induction gave a new impulse to Faraday's mind and gave him confidence in the flights of his imagination which inspired his "Experimental Researches in Electricity". These in turn, translated by Clerk Maxwell into mathematical form, led him to the electromagnetic theory of light and to the conception of electromagnetic waves, which in the hands of Hertz became the basis of wireless.

Faraday's discovery set the inventors' minds working, and one of the first uses of electromagnetic machines was in electroplating. In 1845 Faraday visited Messrs. Prince's works in Birmingham to see the Woolrich generator at work. "I shall never forget", wrote John Percy, "the sparkling delight which he manifested on seeing the result of his purely scientific labours, rendered subservient to a beautiful art and to the advantage of others".

In 1861, foreseeing the need for universal use of a system of electrical units based on certain fixed standards, the British Association appointed a strong committee to investigate the subject. The system of units based on the centimetre, the gram and the second adopted by this committee and the standard ohm constructed by them were afterwards adopted internationally with minor changes. In this way the Association rendered an outstanding service to the progress of electrical science and engineering.

By 1870, with the dynamos of Pacinotti, Siemens and Gramme, the generation of electric current was reaching an economic stage, and its use for lighting by the arc was growing. But it was the invention of the carbon-filament lamp by Edison and Swan that in 1880 gave the first great impetus to the electrical industry. The next landmark was Edison's power station in New York with its D.C. generators providing low-voltage lighting current for the neighbourhood. This was the pattern of development until Ferranti saw that the future of electricity supply lay with the high-voltage transmission of alternating current generated at some convenient point outside a city. No difficulties daunted his inventive brain, and the construction of the Deptford power station with long high-voltage line to London was due to his creative skill. Alternators, cables and transformers were all made to his design, and they ran for thirty years, the prototype of the modern power system.

Meanwhile, Parsons's discerning eye had seen that the marriage of the reciprocating motion of the steam engine to the rotation of the generator was an unnatural union. The turbine had been a dream for at least two thousand years, but, with Parsons's genius for design, in 1884 his first experimental model came like Minerva fully armed. A century before, Watt summed up his sagacious answer to Boulton on the competition they might have from Kempelen's steam turbine with the words: "In short, unless God makes it possible for things to move a thousand feet a second it cannot do much harm". Mechanical progress and Parsons's genius had made the impossible possible, and with it came that smooth continuous high-speed drive that is the key to so much of modern engineering. Forty crowded years of investigation and experience have scarcely changed the profile of the blading that Parsons's intuition shaped in 1896. As Kirchhoff said of Faraday, "He smells the truth". With the turbine and the high-pressure boiler, the polyphase alternator with its rotating magnetic field, and the electric motor, steam and electricity entered on a new age of power.

Energy in the Twentieth Century

The last half of the nineteenth century was a period of continuous expansion. The steady rise in world production, following the law of organic growth, seemed to justify the satisfaction of the Victorians and their optimism about the future. In science, too, the edifice of classical physics seemed almost complete. But the twentieth century was destined to be a time of rapid and revolutionary changes both in science and technology, in which man's use of energy was to play a decisive part. With the turn of the century a series of discoveries gave a new insight into the nature of matter and of energy and their relationship: radioactivity by Becquerel, X-rays by Röntgen, the electron by J. J. Thomson, the nucleus by Rutherford, the quantum theory of energy by Planck, and relativity by Einstein. Those discoveries changed profoundly man's understanding of Nature's processes and gave him new techniques and new tools, which quickened the pace of scientific advance in every field. Meanwhile, the rapid progress of electricity, of the internal combustion engine and of wireless were creating equally profound changes in the social and technical pattern of the world.

The central power station, hydro-electric plants, and the high-voltage transmission of electricity made power available over wide areas both in the factory and in the home. The distribution of power encouraged the dispersal of industry, it substituted for the steam engine the more flexible electric drive, and it gave a great stimulus to mechanized production. The hundred-fold increase in the world's consumption of electricity between 1900 and 1950 was accompanied by a six-fold increase in efficiency of generation.

The gas industry, foreseeing the inevitable loss of the lighting load to its younger rival, concentrated its

efforts on the economical supply of heat and on its by-products. By scientific methods its efficiency has been raised to nearly 80 per cent. In countries that are fortunate enough to possess reserves of natural gas—the ideal fuel—high-pressure mains have been built to carry it great distances. To-day gas provides in all 9–10 per cent of the energy requirements of the world.

In 1900 the production of oil was 20 million tons, by 1925 it had increased to 150 million tons and by 1950 to 500 million tons. Vacuum distillation of oil came in with the new century; by 1930 methods of refining had so progressed that oil could be tailored to meet the needs of the market with an ever-expanding demand for high-octane petrol. Since then, catalytic cracking and the so-called fluid catalyst have set a new high-water mark of efficiency in oil refining.

In 1900 there were less than 20,000 motor vehicles in the world; in 1950 there are 62 million. The coming of the motor vehicle has made a radical change in social conditions from the new mobility it has given to life in every country.

It was, too, the progress of the petrol engine, with its six-fold increase in power output from cylinders of equal size, and the reduction of its bare weight per horse power from 4·5 lb. in 1905 to 1·1 lb. in 1950, which made possible man's conquest of the air and changed the whole relationship of nations by the speed of personal contact it provided; and now, with the coming of the jet, men may fly even faster than the waves of sound. But speedier still is wireless, which carries the human voice across the world in a fraction of a second, while television brings to light the distant scene.

Then in agriculture, the replacement of the horse by the tractor and the use of power on the farm have given a new impetus to development. They have increased the output per unit of labour and thus made good the drift of man-power from the land. In England and Wales the total farm supplies of power (excluding transport) rose from more than one million horse power in 1908 to two million in 1939 and five and a half million in 1948. Of this, horses provided 87 per cent in 1908, 25 per cent in 1939, and only 7 per cent in 1948. In the United States mechanization of the large wheat farms has reduced the labour requirements per acre by three-quarters.

In addition, the availability of energy has made possible a new partnership between agriculture and industry in the processing of farm products. Canning, refrigeration and deep freezing, conditioned transport, crop drying, fermentation processes, and the conversion of farm residues into useful products have all opened new outlets for the farmer.

Side by side with this new pattern of energy in industry and agriculture has come another change no less far reaching—the Domestic Revolution—the scientific application of heat and power in the home, which has done so much in this century to help the housewife and to raise the standard of health and comfort. It may be regarded as the repayment by the technician of a debt long overdue for some of the social evils of the Industrial Revolution.

What measure have we of the significance of energy to man to-day? In the nineteen-thirties the correlation between the average real income and the consumption of energy per head in different countries was so close, with a few exceptions, that it showed how essential supplies of energy are if a reasonable standard of life is to be maintained. Energy is the multiplier of human effort. But its effects are not found in comfort and productivity alone. The rapid interchange of persons and ideas has brought the world together into a much more closely integrated unit. It has quickened the senses and the nerve fibres of nations and given them a new awareness of events, a new world consciousness which in due time must show their inescapable community of interests.

With all these new uses of energy and its growing population, the world's demands are rising daily. How can they be met? Sir John Russell's problem last year of the world's demand for food was simple compared with mine. There is a limit to the capacity of the human stomach, but none to man's appetite for energy; and he finds new uses for it every day.

World Consumption and World Resources of Energy

The world's consumption of every kind of energy to-day, food for men and beasts, heat, light and power, needs a gross yearly intake equivalent to four thousand million tons of coal. On a thermal basis this demand is met by food from agriculture 21 per cent, by coal and lignite 41 per cent, by wood 6 per cent, by oil 24·5 per cent, by natural gas 6·5 per cent and by hydro-electricity 1 per cent; so that about 30 per cent comes from the current revenue of plant and animal growth and water power and the remainder from the capital resources of coal and oil. Leaving aside the work equivalent of human and animal labour, and taking into account the efficiency with which the other energy sources are applied by man, their useful contributions to-day are, roughly, solid fuel 56 per cent, liquid and gaseous fuel 37 per cent and water power 7 per cent.

What of the future? How long can the world's resources meet these growing demands? The world's reserves of coal are ample for centuries. Reserves of oil and natural gas are smaller, and harder to define; but fresh fields are being found, and there is no reason to fear a shortage for some decades. Before then, synthetic oil from coal and the huge reserves of oil in shale will provide substitutes. Turning now from fossil fuels to current revenue, if the world's reserves of water power were all to be developed, their output would equal the total inanimate energy man is using to-day. But these reserves are scattered, and many lie in distant regions far from the crowded areas of the world—in the Belgian Congo, French Equatorial Africa, the Cameroons and South America; and like coal and oil there is a most unequal distribution of resources between nations. The countries north of latitude 20° contain 94 per cent of the world's coal reserves and 83 per cent of the oil reserves, while those to the south contain two-thirds of the world's water-power potential, so that the pattern of development of countries, which must be related to their energy resources, will inevitably be very different.

But our energy problems of the future are not limited to heat and power alone. Reserves of fertilizers for the growth of food and of metals for the machine age in which we live are of equal moment. Fortunately for agriculture the deposits of phosphates and potash will meet our needs for centuries, and nitrogen can be fixed from the air. But again, the reserves of phosphates and potash are most unequally divided, marking the dependence of one country on another.

Reserves of metals may present the world before long with a much more difficult problem. There will be no lack of iron, aluminium or magnesium, although with lower grades of ore the cost may rise. Estimated reserves of copper, zinc, lead and tin are adequate only for some decades, and, if all the world used them at the same rate as the United States, there might be shortages within ten years. Geologists are not optimistic of finding large new ore fields, and so we shall be faced with an iron/light alloy metal economy, reserving certain non-ferrous metals for the uses for which they are essential. Here again, the accidental distribution of ore deposits reveals the interdependence of countries in an acute form.

The global sufficiency of energy reserves is but a poor consolation for the countries that have few. The recent State Department Survey shows that half the world's visible reserves lie in the United States or the U.S.S.R., and another third in nine other countries. Of the remainder, none can claim as much as one per cent, so that their long-term development may call for new techniques. These inequalities are reflected in consumption to-day. At one end of the scale the United States use yearly the equivalent of 9 tons of coal per head, while at the other India and China are using less than one-fifth of a ton per head. The figure for Great Britain is a little more than 4 tons, of which one-third provides domestic needs of heat, warmth and food, leaving nearly 3 tons for transport and industry.

What part is energy to play in the problems the world is facing now—the destruction and disruption of war, the economic unbalance of the older countries, and the claims of the less-developed countries with their ill-nourished millions for a better share in the world's dividends? Energy is essential to increased production both in the factory and on the farm. The needs of the more backward countries are transport, fertilizers, irrigation, heat and power: transport to diversify their social and economic pattern; fertilizers to sustain and increase fertility; irrigation to bring the water on which all life depends; and heat and power to develop their indigenous resources.

The Need for Greater Efficiency

All this means fresh demands. The nineteenth century was wasteful of its easily won materials, but now, thanks to the continuous improvements in technique, the world's demands for heat and power are being met largely by improved efficiency. In Britain until 1938 the total fuel consumption was almost unchanged for a quarter of a century. During that time the population increased by ten per cent. The use of heat and power in industry was extended to secure increased production from human effort. New industries arose, and the standard of domestic comfort increased. The striking fact emerges that the additional energy required with the progress in those years came from the same amount of fuel by increased efficiency of use. But, as the war-time economies proved, there were still great improvements to be made, and that is still true to-day.

What are the prospects of meeting future demands by improved efficiency of existing practice, by the transport of energy or by new methods and new sources? To simplify the problem I will discriminate between the four energy industries—coal, electricity, gas and oil—and the uses of the products they provide. It is in the energy industries that the major advances have been made. The most modern types of plant in each have reached a point where only fractional progress is likely to be made, and where the limits may be the discovery of new alloys or the higher cost which the gain in efficiency would not justify. There are still large savings to be made by raising the standard of all plant to that of the best practice. The generation of electricity has a special problem of its own—the loss in the cooling water of the condensers of about sixty per cent of the heat employed. Where steam is needed for any purpose in addition to power, this loss can be avoided by using steam from the low-pressure side of the turbine instead of condensing it. In industries using steam, the generation of electricity before the steam is used for heating purposes would secure large fuel economies. The other plan of using low-grade heat for district heating involves heavy capital costs if it is introduced in built-up areas, unless hot-water heating systems are already installed; but it would be more attractive in new development schemes with a sufficient density of population. With the continuous increase in the demand for electric power and the heavy capital cost of generating equipment, the problem of the combined use of heat and power is of major importance.

Turning now from the energy industries to the use of heat and power in industry, in transport and in the home, it is there that inefficiencies of one kind or another combine to make the overall efficiency of use in Britain probably less than 15 per cent. Here is the urgent need for large economies to save the coal that will be needed for increased production. The future of British industrial efficiency will be closely linked with the efficient use of coal, the main raw material on which British prosperity depends.

To-day's Developments

Before looking to the future, let me touch on a few developments that lie immediately ahead. The gas turbine, a new prime-mover, has proved itself for aircraft use both as turbo-propeller and turbo-jet. Several land and marine types are now being developed to use gaseous, liquid or solid fuels. It has the advantage of compactness, it can be used where no cooling water is available, and it is specially suitable for burning by-product or waste gases. Underground gasification of coal is being tried in several countries, and, if successful, the gas turbine may possibly be the best means of utilizing the gas obtained. In Britain much depends on the success of the gas turbine using coal by one means or another.

Kelvin's heat pump, the refrigerator in reverse, with its high efficiency of power in supplying domestic heat is now on trial. Its economy is greatest in latitudes where its use for air-conditioning in summer balances its use for heating in the winter. In industry, too, the principle of the heat pump is being applied with great economy to recover the heat lost in evaporation.

In Italy the internal heat of the earth has been used successfully in a geothermal power station on an ever-increasing scale for more than thirty years. Difficulties and dangers in drawing steam from great depths and using it have all been overcome. Italian engineers and men of science have set a great example that could be followed wherever thermal springs or volcanic steam are found.

Few advances have been made in using wind power, one of the earliest forms of energy used by

man; but now, with the progress in aerodynamics, new experiments are being tried which may produce power economically to be fed into a grid system and thus save coal. At favourable sites in Britain it is expected that wind-driven generators weighing about 300 lb. per kW. will produce 4,000 kWh. per kW. per annum.

Future Possibilities

What new means of tapping Nature's stores of energy are likely to emerge and bring it where it is needed? The unequal distribution of energy sources will make its transport of increasing importance in the future, and here the possibility of transmitting electric power over long distances by high-voltage direct current has passed the experimental stage and is waiting for development. By this means it should be possible to transmit large blocks of energy economically for perhaps a thousand miles by underground or submarine cable and thus link consuming centres with new and distant sources of hydro-electric power. There is, too, the interesting possibility of linking the British and European Grids and thus securing a better balance between capacity and requirements by taking advantage of the seasonal variations in capacity and the diversity of demand. Such a scheme would, of course, be complementary to the distribution of power by alternating current, and it offers an opportunity for the British to share in European co-operation without raising the delicate problems of supra-national authority. A link of 250,000 kW. capacity should be of mutual service to both sides by providing the equivalent of a large modern generating station as stand-by plant.

The tides in favoured spots are obvious sources of energy, and, if more courage had been shown in pre-war years in carrying out schemes like the Severn Barrage, they might to-day be economical and saving fuel.

Then, it is tantalizing to think of the immense amount of energy reaching the earth by solar radiation, and the small use we make of it. The energy reaching the earth's surface is some 50,000 times as great as our consumption. Forty per cent of it is used in evaporating water and one per cent in lifting it into the atmosphere, whence we derive our water power. Most of the rest is absorbed and lost by radiation in the night. One per cent of the radiation falling on vegetation is used in photosynthesis, whence we derive our food and fuel. Many experiments have been tried to make more use of solar radiation—its concentration by mirrors to give high temperatures, its storage in hot water or melted salts, and the generation of electricity by the photo-electric cell or thermocouple. None has so far produced an economic solution, but sunshine is so often available at places remote from other energy sources that we surely have a duty to posterity to pursue long-term researches in this field while we are living on reserves.

One large-scale experiment in using solar radiation is being made by the French Government on the west coast of Africa. A turbine will be driven by steam obtained by evaporating under vacuum the warm surface water of the sea at 28° C., the condenser being cooled by water at 8° C. drawn from a depth of 400 metres. Another interesting possibility, in Egypt, is to drive turbo-generators in the Qattara Depression by water drawn from the Mediterranean forty-five miles away, relying on solar radiation to evaporate the water from the tail-race as it accumulates in the Depression.

Last year Sir John Russell spoke of the possibility of raising the efficiency of plant photosynthesis to produce more food in a given area. Experiments have shown that this is possible with certain algæ, but the land-grown plant supplies the structure of its own factory and draws its own raw materials from the air and ground. The use of algæ would be an industrial process, and the land-grown plant may prove to be the more economical in operating costs. However, the work on algæ is in its infancy, and it would be premature to speculate about its economy.

Mayer ended his short prophetic paper in 1842 by saying that the inefficiency of the steam engine justified the attempt to produce 'motion' by other means than the sacrifice of carbon and oxygen, for example, by electricity obtained by chemical means. An economical fuel cell in which the free energy of the oxidation of carbon is converted into electricity has so far evaded discovery, but it remains one of the long-distance goals of research.

Nuclear Energy

The story of nuclear energy shows what can be done if science is used lavishly with all the resources of the modern world to penetrate Nature's secrets. Now, having wrested Nature's secret from her, comes the task of using her great storehouse for the good of man. I need not dwell on the advantages of that concentrated source of energy, with a potential several million times that of coal, if it could be tamed. Energy could be taken to remote places of the earth when it is needed. Deserts lacking only water might be made a paradise. But to-day the unsolved problems of these peaceful uses loom so large. Once more we see how hard it is to be creative compared with the ease with which man can destroy.

It is clear from the discussion at the Fourth World Power Conference, held in London this year, that the difficulties to be overcome before the use of nuclear energy becomes economical are most formidable, and their solution will require intense effort over a long period. New engineering materials must be found with properties never before investigated or required. They must be stable over long periods under intense neutron bombardment and must not cause loss of neutrons by absorption. The removal and disposal of the radioactive products from the reactors will be a costly and puzzling task. With the world's need of energy, it would be a tragedy if the fear of competition from nuclear piles were to delay in any way the immediate development of the more conventional and better understood sources of energy. It may well be that the first use of fissile elements will be to transport energy to places far remote from other sources. Meanwhile, the nuclear plants are yielding good dividends in the radioactive isotopes they produce. These provide a most powerful new technique of research, which has given us both a new understanding of many of Nature's processes and new methods of production control.

Auto-Mechanisms

The by-products and radiations of these nuclear plants are so dangerous to life that their operation

is only made possible by automatic controls. This brings me to the latest chapter in man's use of energy, the new science of auto-mechanisms, which can replace the human senses and control machines. These modern robots may seem to bring us nearer to the fear of "Erewhon" of the mastery of the machine; but, just as the machine was the saver of manual labour, they are substitutes for the drudgery of the human brain. To-day the energy of the electron is harnessed by photo-cells, by radar pulse and other means through valves and amplifiers to watch and act. Usually these devices are more accurate than the human senses, and their action in micro-seconds eliminates the slow reaction time of man. They leave an automatic record, too, of what they have done. But in claiming the superiority of these man-made mechanisms for their specific purpose over man himself, I must make one exception. No auto-mechanism has, I think, approached the delicate perception of the sensory organ with which chemists are so well endowed—"Their noses infinitely wise. Their minds being memories of smells".

In any task that they are set to do, these controls must be fed with information to tell them when to act and the result. For example, in drawing wire through a die at constant tension, the auto-mechanism must detect a change of tension and at once adjust the speed of reeling-up until it knows the standard tension has been reached again, just as the senses tell the muscles how far their task has been performed. There are even electronic mechanisms to simulate the performance of their own kind and say how well, or ill, they do the work for which they are designed.

Sometimes the task is not so simple and calculations are involved, and these the electronic computer can do much faster than the human brain; and there are calculating machines with electronic memories which can be set to make most complex calculations which would be impossible by human means owing to the time involved. These electronic computers can perform set tasks without ability to think. Errors may occur if a vacuum tube burns out or a switch fails to act, and now a new device enables them to detect such errors, locate them and correct their own mistakes.

This latest venture in the use of energy must have most far-reaching effects. These automatic controls and precision techniques, consuming almost negligible quantities of current, will save man-power and add greatly to the economy of production, thus reducing the quantity of energy required. In the future, one of the indexes of economic progress should be, not the energy used per worker, but the output of goods and services per horse power employed.

Energy and the Future

Now, as I near the end of my address, I wonder, have I claimed too much for progress—progress, that missing word among the Greeks? Have we replaced the Golden Ages by an Age of Steel? Has man's use of energy brought happiness or not? There is no yardstick that can tell us, in Priestley's phrase, whether the "greatest happiness of the greatest number" has increased. We see the contrast of man's swift advance in understanding Nature and the troubles of the world to-day. Is the myth of Dædalus for ever true? Sir Arthur Keith ends his "New Theory of Human Evolution" with the words: "In the clash and turmoil of this modern world we are hearing the creaking wheels of the machinery of evolution". Is it inevitable, as he concludes, that in this great revolution through which we are passing the old primitive enmity of nations, the urge to self-sufficiency, will grow stronger? What ground is there for hope?

Once more I turn to Carnot's essay for the answer. In 1824 he wrote: "Navigation due to the steamship has in a measure drawn together the most distant nations. It tends to unite the peoples of the earth as if they lived in the same country". His prescient eye had seen that energy would bring the world together. We see to-day the stirring of a new world consciousness that must in time bear fruit, a new awareness of the load the modern Atlas has to bear, the problems we must face: the growing strain of increasing population, the malnutrition and endemic sickness of perhaps half the world, the inequalities between the more forward and the backward peoples, the gradual depletion of resources and their unequal distribution, and, by no means least, the human problem of changing the way of life and outlook of many millions. The hope lies in man's new understanding of Nature's processes, in his more efficient use of her resources and in the growing recognition of the dependence of one nation on another. Wendell Wilkie saw this so clearly in his classic phrase: "to raise the standard of living of one man anywhere in the world is to raise the standard of living by some degree of every man everywhere in the world".

These problems are the challenge to the science and engineering of our time. Only they can solve them—if allowed, and if men's minds are bent on quest of plenty not on quest of power. That is the issue for the world to-day, a world so divided for the moment. The orderly solution of these problems must depend on a knowledge of conditions and the needs of each country, on a survey of its natural resources, its human geography, its economic structure and its capacity to produce and consume. The limiting factors will then appear, and the problems they present can be attacked in their priority. The over-riding importance of such surveys is slowly being recognized, and the technique of making them is under way. Much material of the kind has already been collected by individual countries, by industries and by the agencies of the United Nations. Eight years ago I wrote: "Unless all this information is brought together to a central point—a United Nations Economic Bureau—it will remain uncoordinated, with unknown gaps, and there will be no comprehensive picture which may serve as a basis for the processes of reconstruction which will merge gradually into the processes of international trade". That is still true to-day, and last September at Lake Success many speakers emphasized the need for such inventories of world resources so that each country might know the resources and potentialities of the rest. Only in this way can the natural wealth of the world, distributed in such an accidental way, best be used to meet its ever-growing demands.

In all these plans energy will play a vital part. So often its availability will dictate the pattern of development. It may well be the limit, in Bacon's words, "to the effecting of all things possible". Throughout the ages it has been the key to progress, and it has not lost its power. On man's wise use of energy depends so much the future of this troubled world.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

MATHEMATICAL NOTATION

IN his presidential address to Section A (Mathematics and Physics), Prof. E. H. Neville discusses mathematical notation.

The great contribution of the nineteenth century to the subject was the acceptance of the non-numerical variable. Evidence of the belief that the variable must be in some sense numerical survives in the name of the complex number, and is to be found also in early writings on matrices and on quaternions. Cayley speaks of "the matrix considered as a single quantity", and it was not until the matrix was presented as an operator transforming one set of variables into another that it had the individuality which qualified it to be the element of an algebra. The same sort of individuality was conferred on the complex number by Argand and Wessel to end the scandal of 'the square root of minus one'. The adventurous calculus of operations of the nineteenth century was chopped to death by logic, but not before the enlarged conception of the variable was firmly established.

Notation is not right or wrong, but only good or bad. The most irritating of notational misfortunes are those where we should all like a slight modification in a usage that has become classical. No one can doubt that if we had a free hand to-day we should have a symbol for the radial measure of one right angle, not of two; the economy would be incalculable. William Jones is not to blame, nor even Euler, for the evidence is cumulative and was not in their possession; now it is too late to make a change. The case of the gamma function is more complicated. Gauss' Πx is identical with Legendre's $\Gamma(1 + x)$, and there is no doubt that Gauss' argument is the more convenient: to quote Jeffreys, the 1 which Legendre took over from Euler is "a minor but continual nuisance". We can agree to Gauss' form of the function but not to his appropriation of Π; the notation $x!$, which is gaining currency, creates difficulties of its own.

If two symbols are equivalent it does not always follow that one of them is redundant, and however closely two functions are related there may be sound reasons for retaining symbols for them both; a mathematical sense of proportion is often exhibited in the play made with alternatives. The theory of elliptic functions needs both the classical notation K, iK' and the structural notation K_c, K_s for quarterperiods; we can seldom make the best of two worlds unless we can speak two languages. In the same theory, we cannot express satisfactorily the theorems which depend only on the period lattice and also the theorems which depend on the labelling of this lattice unless we have symbols both for the parameter c and for the modulus k, although c is only k^2. The most notorious illustration of this principle is the scalar product of two vectors; the physicist and the engineer need the product $ab \cos c$; but it was sheer ignorance to suppose that Hamilton could have accepted this product rather than its negative as fundamental in his calculus.

The most far-reaching innovation in formal symbolism in the present century has been Einstein's summation convention, which reduces to manageable proportions the labour of applying the tensor calculus, and has effected great simplifications in the presentation of co-ordinate geometry, of vector algebra, and of the theory of determinants. This convention operates within the field of the traditional notation of mathematics. The really revolutionary change that has been taking place at the same time is the permeation of mathematics by the symbolism of logic. English mathematicians have learned from "Principia Mathematica" that this symbolism not only provides systematic abbreviations for phrases in perpetual use, but also compels a careful analysis of the assertions to be expressed and incorporates an inferential calculus which can lead to an immense economy of actual thinking; the notation for orders of magnitude carries out these same tasks in its own sphere.

While logical symbols are being used more and more in the older parts of mathematics, newer subjects are tending more and more to ideography. In topology, in group theory, and in algebra in the modern sense, theorems which would have been enunciated verbally in 1900 are now enunciated symbolically. The notation controls the emphasis, reduces a long-winded corollary to a brief formula, renders accessible regions which it would have been humanly impossible to explore with words alone. These developments belong to groups of specialists rather than to the whole community of mathematicians, but it is the freedom of the community from conventional restraints in the use of notation that has made it possible for the groups fully to satisfy their own needs.

MODERN DEVELOPMENTS IN CARBOHYDRATE CHEMISTRY

THE period between the two Birmingham meetings of the British Association in 1913 and in 1950 has been noteworthy for the surprising progress made in the chemistry of natural products. This has been specially marked in the carbohydrate group, and the main theme of Prof. E. L. Hirst's presidential address to Section B (Chemistry) is the development of the ideas and methods which have rendered possible the present-day knowledge of the structure of the simple and complex sugars. This knowledge, so widely spread in industry, biology and medicine are the ramifications of carbohydrate chemistry, is of vital importance for the solution of problems in many other fields of inquiry. At the time of the Birmingham meeting in 1913, progress in the chemistry of the simple sugars was retarded by lack of precise knowledge of ring structures, and only the most meagre information was available concerning the disaccharides and the polysaccharides.

New methods of attack were necessary, and the requisite pioneer work, which enabled the unsubstituted reactive hydroxyl groups of sugars to be rendered chemically inert without alteration of ring structure, was carried out in the St. Andrews laboratories by Purdie and Irvine. Oxidation of the fully methylated methylglycosides was then investi-

gated and developed into a general method for the determination of ring structures. By means of this technique and ingenious modifications of it, such as the oxidation of the fully methylated aldobionic acids in the disaccharide group, the workers of the Birmingham school, under the late Sir Norman Haworth, in a comprehensive series of investigations, determined the structures of the stable methyl glycosides (later termed pyranosides from the six-membered ring present in the molecule), the furanosides and the important naturally occurring disaccharides and trisaccharides such as cellobiose, maltose, sucrose, gentiobiose and raffinose. In many cases alternative methods, analytical and synthetical, afterwards provided confirmatory proof of the accuracy of the results obtained by the methylation method. One of the most versatile of the newer techniques is oxidation by periodic acid, introduced by Malaprade for the oxidative degradation of glycols. Besides numerous important applications in the mono- and oligo-saccharide groups, this reagent is of special value in the study of the complex polysaccharides; for it can be employed to gain quantitative evidence of the presence of end-groups, and, by examination of the hydrolysis products obtained from the oxidized polysaccharide, information can be obtained concerning the mode of linkage of individual residues in the polymer.

Another recent development of the greatest importance to carbohydrate chemistry is the use of chromatography for the quantitative separation of mixtures of sugars, whether unsubstituted or in the form of their methyl ethers. So delicate and accurate has this technique become that for the time being a limiting factor in the study of the complex carbohydrates resides not so much in the separation and classification of the various sugar residues as in the difficulty encountered in hydrolysing the polysaccharides without damage to the component sugars. Besides applying these methods to the undegraded polysaccharides, present-day investigators attempt to simplify their problems by examining the structure of degraded fragments obtained by partial hydrolysis.

In those ways, aided also by highly specialized physico-chemical techniques such as X-ray analysis and sedimentation in the ultracentrifuge, sufficient information may be gained on which to base the general structure of a polysaccharide. In some cases, for example, cellulose, which consists essentially of long chains of β-1,4-linked glucose residues, the structure is known in some detail; but even here there remains a fine structure of great importance to the industrial chemist about which little is yet known. The main structure of the amylose component of starch (α-1,4-linked glucose residues) is also known with some certainty. Much still remains to be learned concerning the amylopectin component of starch with its many branched chains and five per cent of its glucose residues present as end-groups.

Reference has been made to the special problems presented by the xylans, arabans, pectins and alginic acid, and it has been pointed out that, difficult as all these problems are, they are simple in the sense that each polysaccharide contains only one kind of sugar residue. The plant gums and mucilages and many polysaccharides of importance in chemotherapy present much more complex problems in that they contain a variety of sugar residues, and it is therefore necessary to ascertain the order in which these are united together in the molecule. Only a beginning has yet been made with structural studies on these groups, and Prof. Hirst concludes with a review of the position now reached, with special reference to the chemistry of gum arabic.

STONY METEORITES

DR. W. CAMPBELL SMITH, in his presidential address to Section C (Geology), points out that among the thirteen hundred or so known meteorites recorded in the past hundred and fifty years, some seven hundred and sixty are 'stony meteorites' consisting mainly of ferromagnesian silicates. The elements found in meteorites do not differ from those known on the earth, and the silicate minerals of the stony meteorites are varieties of the same species as those found in basic and ultrabasic igneous rocks.

About ninety per cent of all stony meteorites contain varying proportions of nickel–iron, ranging from 4 to 25 per cent, and these (with half a dozen exceptions) are characterized also by the presence of small, spherical bodies ('chondrules') consisting of pyroxene or olivine, or both together. These meteorites are called chondrites. Their chondritic structure and nickel–iron content make them quite unlike any known terrestrial rocks. The remaining ten per cent of stony meteorites, containing no chondrules, are called 'achondrites'. Some of these show a partial resemblance in mineral composition and texture to igneous rocks. By applying to them the methods used in the study of igneous rocks and rock-forming minerals, we may hope to obtain some insight into the conditions under which meteorites were first formed and what changes they have since suffered.

One group of the achondrites, the eucrites and howardites, represented by about twenty-five falls, comprise meteorites of which the constituent minerals are feldspar (bytownite–anorthite) and pyroxene (mainly pigeonite). They are, with one exception, intensely brecciated; but they contain many fragments which resemble in texture some ophitic dolerites and basalts, and these are regarded as products of direct crystallization from molten magma.

The other achondrites contain little or no feldspar, consist of magnesium–iron–pyroxenes and olivine, and, except when brecciated, present a holocrystalline granular texture. Their mineral assemblage falls almost wholly within the MgO–FeO–SiO_2 system fully investigated experimentally by N. L. Bowen and J. F. Schairer. The conditions of crystallization of the several phases in this system show that one cannot explain the crystalline granular achondrites as the result of direct crystallization from a magma of their own bulk composition. They must be regarded rather as the result of crystal-settling in a differentiating magma. Such a process requires not only bodies of magma of considerable size but also a gravity field sufficient to make settling of crystals in a magma possible. Both requisites imply that the material of these achondritic meteorites formed within a body comparable in size with our earth.

A similar settling of magnesium silicate minerals, but mixed up in some way with nickel–iron, may account for the original materials of the chondritic meteorites; but their subsequent changes in com-

position and structure, resulting first in a transfer of iron between nickel–iron and silicates, and later in the formation of chondrules, are more difficult to explain. G. T. Prior found, as a result of a survey of the chemical composition of stony meteorites, that "the less the amount of nickel–iron in chondritic stones, the richer it is in nickel and the richer in iron are the magnesium silicates". Prior attributed this relationship to progressive oxidation of metallic iron acting for different periods or at different rates. One must suppose that such reactions proceeded in bodies of considerable size which had, owing to different conditions, varying opportunities for interchange between metal and silicate. Such different conditions may imply that the bodies were separate and travelling on different paths. However this may be, the resulting silicates of the chondrites correspond to only part of the achondrite series, ranging from pure enstatite to the hypersthene–olivine assemblages with MgO : FeO from $2\frac{1}{2}$ to 4. The more ferriferous magnesian silicates are not represented among chondrites, and nickel–iron is never entirely absent from them.

The chondrules, whether of orthopyroxene or olivine, appear, so far as available evidence goes, to have compositions similar to those of the silicate minerals with which they are found. This implies that they were not formed until after the silicates had reached their present composition.

Many theories have been advanced to explain the formation of chondrules. Some, consisting of radiating enstatite prisms, appear to have crystallized rapidly from globules of molten pyroxene; others with porphyritic and granular olivine crystals in a glassy fine-grained base may have crystallized more slowly from larger parts of the mass which were thereafter broken up and rounded by attrition while still soft. The conditions for their formation may have developed when the course of the bodies broken from the parent planet passed near the sun, which caused intense heating and violent fusion accompanied by ejection of molten globules. After cooling became possible, the chondrules must have been gathered back into the mass from which they came, for the meteorites now consist of chondrules in a matrix of broken fragments of pyroxene and olivine, and of broken chondrules as well, with varying amounts of nickel–iron and troilite, the whole forming a compact though sometimes friable stone.

Subsequent to the first crystallization of the achondrites and later than the formation of chondrules in the chondrites, there occurred, in most stony meteorites, intense brecciation, re-heating (sometimes repeated) and the formation of thin black veins which have been compared to the pseudotachylyte veins found in some great granite masses and attributed to crushing in bodies of rock of considerable size. In the case of the chondrites, these effects must have taken place after the break-up of the parent planetary body. There may have been more than one period of break-up, and one must be prepared to consider, as a possible cause both of brecciation and re-heating, violent changes of temperature due to passage close to the sun of masses still of considerable proportions. The final break-up into meteorites of the size known to us from actual falls came at a still later stage.

None of the structures here described is attributable to heating effects caused when meteorites enter the earth's atmosphere. These are restricted to the 'burning away' of the outer part of the meteorite, disruption with explosive violence, the formation of the peculiar pittings ('thumb-marks') and, last of all, the solidification of a thin glassy crust coating the surface of the stone.

THE SCIENCE AND PRACTICE OF ENTOMOLOGY

ENTOMOLOGY in Great Britain remained for long enough the care of amateurs, and when the scientific teaching of zoology in the universities was being established during the second half of the last century, the insects were largely neglected. That was unfortunate, because the insects compose a majority of the known species of animals; they are exceedingly diverse in form and habit and well suited to illustrate, often in the most vivid form, most of the problems with which the student of living things is concerned. Indeed, at the present time, insects are being used to an ever-increasing extent as a medium for study by chemists and physicists, geneticists, experimental zoologists, physiologists and biochemists; above all, they furnish exceptional material for the study of animal behaviour and ecology. In his presidential address to Section D (Zoology), Dr. V. B. Wigglesworth discusses "The Science and Practice of Entomology".

The period during which zoology became established in the universities of Great Britain was also a period of rapid development in large-scale agriculture and of improvements in communications, with the consequent emergence and dissemination of insect pests. The change was heralded in the 1860's by the transformation of the harmless Colorado beetle into a major pest of agriculture, sweeping across the American continent and, to-day, across Europe. The production of Paris green as an agricultural insecticide was the result, and since that day the insect pests of agriculture have become ever more prominent and the insecticides and other methods of control more powerful. During this same period we have become increasingly aware of the importance of insects in carrying disease to man and his livestock, in consuming large quantities of our stored foods and other produce, and in destroying structural timbers. The insects have surely come into their own—in both pure and applied science.

If this field of science is to be exploited to the full, we must turn out entomologists who know the world of insects in the round; who are at once morphologists, taxonomists, physiologists and field naturalists. These men will find that the world of insects is in a state of flux; that the species tails off into the 'biological race', that species are continually changing in abundance and, apparently, in habits and certainly in the amount of damage to human interests they bring about. It follows that the applied entomologist must be constantly investigating, that *applied entomology is research*. Once a problem has been solved, the preventive procedure can often be incorporated into the practice of the industry in question and the entomologist is no longer required. He will always be confronted with new problems for solution and must therefore always retain the outlook of the investigator.

This thesis has important implications in the field of practice and administration. The dissemination of existing knowledge in the form of advice by the

applied entomologist is not enough. Existing knowledge is too inadequate. In all the fields—agricultural entomology, insect pests in stored products or in timber, the locust problem, and the rest—we need an unbroken chain of research workers at all levels from the theoretical to the practical; and the entomologists at the most practical end must be shielded from petty incursions upon their time, so that they may get on with their proper work of investigation. For the entomologist in the Colonies there is the added need for contact with libraries and centres of research in Britain and elsewhere if the stimulus to investigation is to be maintained.

But is entomological research still necessary in the applied field? Or is the entomologist, in fact, outmoded by the discoveries of the organic chemist in the realm of insecticides? The discovery of the insecticidal properties of DDT, 'Gammexane' and the organophosphorus compounds respectively in Switzerland, Great Britain and Germany has transformed the control of insect pests during the past ten years. But it is becoming increasingly evident that the use of more and more insecticides is creating insect problems as fast as it solves them. We can probably control any specific orchard pest, for example, with which we have to deal—but the problem of orchard pests in general gets worse. There is, in fact, increasing scope and need for entomological research—to guide intelligently, to supplement, and sometimes even to supplant the application of chemical measures of control by the more subtle and more remunerative methods of biology.

THE UPLAND PLAINS OF BRITAIN: THEIR ORIGIN AND GEOGRAPHICAL SIGNIFICANCE

PROF. S. W. WOOLDRIDGE surveys some of the problems of the later stages of landscape evolution in Britain, and particularly the evidence afforded by well-marked erosion surfaces developed over a wide range of altitude, in his presidential address to Section E (Geography). Though much work has been done on these surfaces both by geologists and geographers, the evidence as a whole has not yet been faced, nor general conclusions proposed. It is clear that no adequate reconstruction of the stages of development of the British land-surface can ignore such evidence; the partial explanation frequently proposed tends to hark back to older structural episodes which are, in fact, largely irrelevant to the question.

The key area is south-east England, where a widespread surface of marine planation at about 600 ft. retains traces of a cover of known (Newer Pliocene) age. Above it, the summit areas retain remnants of an earlier peneplain, while at lower elevations there are extensive remnants at about 400 and 200 ft. O.D. respectively, the former being evidently of late Pliocene or early Pleistocene age. The Bristol district exhibits remnants of upland plains at the same three altitudes and also at 750–800 ft. In east Devon the sequence of surfaces is fuller, as shown by J. F. N. Green, who distinguished six 'platforms', interpreted as marine strand-flats, between 500 and 1,000 ft. O.D. The evidence is continued farther west in Devon and Cornwall, where platforms at about 1,000, 800 and 400 ft. have long been known. The west-coast areas from Cornwall northwards to Cumberland, and parts of the Irish coast, reveal a closely similar succession of platforms, and there are indications of the occurrence of some of them in Scotland. No similar evidence is available from the east coast of England, the region having presumably suffered tilting or warping towards the North Sea depression. Over much of the rest of the country, however, there is evidence of long-continued stability, involving either uniform uplift of the land or a spasmodically sinking sea-level.

It is concluded that the major platforms up to a height of 1,000 ft. are, in general, of marine origin and not older than Pliocene in age, though the higher summit planes of the Welsh mountains, Pennines, etc., most probably represent surfaces of sub-aerial planation of earlier Tertiary date. The acceptance of these conclusions carries important implications for geophysics and stratigraphical geology, as well as geomorphology. In the latter field, they afford an outline of a coherent story of the earlier stages of coastal evolution and throw much light on the development of river systems. Further, it is manifest that if the several 'upland-plains' of Britain represent surfaces exposed for periods of differing duration to soil-forming processes, physiographical analysis is vitally relevant to the study of soil character, and therefore of considerable importance to the plant ecologist as well as to students of land utilization and land classification.

ECONOMIC PROGRESS: RETROSPECT AND PROSPECT

IN his presidential address before Section F (Economics and Statistics), Prof. G. C. Allen points out that statistical investigations, as well as common observation, show that a great advance in income per head took place in Great Britain in the half-century before the Second World War. Even in the years between the two World Wars, which are often mistakenly looked upon as years of stagnation, there was probably a rise of about 25 per cent in real income per head. The main cause of this improvement was the growth in industrial productivity; it has been estimated that, between 1907 and 1937, output per man-hour grew by more than 80 per cent in real terms, and most of this increase occurred after 1924.

It was this experience which led to the optimistic forecasts of our economic future that were made shortly before the end of the Second World War. Our troubles since 1945 have, however, produced a more gloomy mood, and this has been intensified by the results of various inquiries which have revealed weaknesses in our industrial capacity, especially in comparison with that of the United States. Many of these weaknesses have been attributed to our unsatisfactory or obsolete equipment, and it is commonly asserted that they can be removed only by greatly increasing investment in our under-capitalized industries. While capitalization and productivity are, of course, very closely linked, it is doubtful if the above diagnosis is entirely adequate; for our productivity is lower than that of some other countries, even in industries in which there is no wide disparity in the amount of capital used per worker.

A deeper cause of our inferiority, it is suggested, is to be found in defects in our use of the resources already available to industry, and this means a failure of industrial leadership. It is fertility in resource and imaginative enterprise that lie at the roots of material progress. The backward countries of the world are in that position not so much because they lack capital as because they lack industrial leaders. In a country like Great Britain, which cannot now lay claim to any superiority in natural resources over many others, and which is being overtaken by numerous competitors in the old-established industries, it is the capacity to carve out new channels of enterprise upon which material progress will depend. The most disquieting feature of the inter-war situation was not that our old industries, in which we were once supreme, declined, but that we did not achieve a foremost position in the new industries that appeared during that time.

The chief contribution to material progress in the future is likely to be made, as it was made in the past, by the industrial leader who uses resources for *new* productive purposes, and whose massive innovations force the ordinary run of business men out of their routine and so raise the level of efficiency throughout an economy. A society which impedes this kind of activity on the part of the innovators cannot hope for great improvements in its material standards. In recent decades Great Britain has lagged behind other nations in industrial leadership. Our position in established industries has been undermined by developments that took place abroad rather than at home, and, in spite of our scientific achievements, we have not shown the capacity of our fathers, or of the industrialists of some other countries, in creating new industries. Since our progress in material well-being in the decades ahead is likely to be substantial only if we show exceptional competence as industrial pioneers, this is a cause for grave concern.

It may be that the day of the private entrepreneur, in his role of innovator, is over in Great Britain, and we have to ask whether his function can be performed by some other agency, for example, by the State. In some of the more primitive countries, governments have certainly performed this function with success. But, in those countries, the task has been that of introducing techniques and forms of organisation already worked out elsewhere. Whether governments can be equally successful in developing entirely novel kinds of industry within advanced societies has yet to be shown. Success depends largely upon the selection of the right men for responsibility; and those who in the past have done most for the world in this field have had to work their own way to the light, often in the face of opposition or scepticism on the part of their well-established contemporaries. New industries, for example, have not normally sprung from large, established concerns, but have usually been built up from small beginnings. The government cannot easily select the right men when they are still unknown and untried for heavy responsibilities, and yet it is from such men that great industrial innovations have usually come.

In the end, whether it is left to the government or to private entrepreneurs, successful innovation has, as its first condition, the existence of a society which welcomes it and which is sufficiently cohesive to withstand the disruption of old ways of life that innovation causes. Whether any particular society possesses the morale which makes it possible to preserve social stability in the face of far-reaching technical changes, just as whether it possesses the energy and will which drive forward a people in the pursuit of material progress, are questions that cannot be considered primarily in the context of economic calculation.

A CHAPTER IN BRIDGE ENGINEERING A CENTURY AGO

PROF. A. ROBERTSON begins his presidential address to Section G (Engineering) with the reminder that a hundred years ago, in March 1850, the Brittania Tubular Bridge was opened. In the previous year the report of the commissioners appointed to inquire into the application of iron to railway structures was published. Both are notable instances of the collaboration of engineer, constructor and mathematician which has been so fruitful in engineering. The Bridge was an impressive advance on previous work, not only in size but also in the material of which it was constructed and the manner in which it was erected. In order to complete the Chester and Holyhead railway, the Menai Straits had to be crossed. By making use of the Brittania Rock, the longest span could be kept down to about 470 feet. Robert Stephenson's original proposal of a cast-iron arch (which would have been twice the span of any existing arch) was rejected, and an Admiralty commission demanded a clear passage throughout the whole span of a hundred feet above high water.

Stephenson conceived the idea of a tube (through which the train would pass) which might need to be supported by chains during erection and possibly retained as a permanency. Such a bridge would have to be in wrought iron, although the longest wrought iron bridge at that time was only about sixty feet. He decided on a series of experiments which he placed in the hands of William Fairbairn, who later called in Eaton Hodgkinson. Tubes of 12–24 in. in diameter and 25–31 ft. long were made by rolling sheet to a thickness of 0·037–0·135 in. and then riveting. They were tested in bending by a central load. The tests brought into prominence the phenomenon of wrinkling, that is, the portion under compression failed by crumpling up into folds. Further tests were done on elliptical, square and rectangular tubes. It was decided to build a model one-sixth full scale, 75-ft. span, having a cellular top (compression side) and a single plate for the bottom. The model was tested under a central load. In the first test it fractured under 35·5 tons. Alterations were made, and in the final test the load was 86 tons, corresponding to a stress of 14·8 tons per square inch on the compression side and 18·6 on the tension side.

The final design for the bridge consisted of a series of cells for both top and bottom booms, separated by side plates which were stiffened with vertical angle-iron and gusset plates. The cellular construction was necessary because plates could not be obtained thicker than $\frac{3}{4}$ in. The tubes were constructed on stages built on the shore, so placed that pontoons could later be brought underneath the tube. The first tube (412 ft. long, and actually that for the Conway River) was proof-tested with a load of 300 tons over the middle 300 ft. In order to devise the best way of navigating the pontoons on which

the tube would be carried from the shore to the site, a model of the Straits was constructed and the position of the necessary winches, etc., was settled. On reaching the site, the pontoons were released and the tube rested on the masonry of the base. The tube was raised to its correct height by means of long chains depending from hydraulic presses fixed in the towers. The several spans of the Brittania Bridge form a continuous girder, and this advantage was used when the tubes were finally joined together.

The cellular construction devised for the bridge was adopted by Brunel in 1854 for his ship the *Great Eastern*, which in displacement was five times that of any vessel then being built and fifty years ahead of her time. Structurally she was a great success.

Before the Britannia Bridge, most railway bridges were built of stone, brick, timber or cast-iron. For many of the short ones, cast iron was used as a beam, and for some (up to about a hundred feet long) several castings were bolted together. Sometimes these were designed with a trussing of wrought-iron tension bars. The failure of a bridge of this type led to the appointment in 1847 of a Royal Commission. The important clause in the terms of reference was: "They shall endeavour to ascertain such principles and form such rules as may enable the engineer and mechanic, in their respective spheres, to apply the metal with confidence and shall illustrate by theory and experiment the action which takes place under varying circumstances in iron railway bridges which have been constructed". This clause excited considerable opposition among the engineers of the day who feared the possible formulation of rules to be observed.

The Commission concerned itself almost entirely with cast iron, and deliberately refrained from expressing any opinion on wrought iron. It instituted a series of valuable experiments on such varied topics as: the repeated application of load with and without impact, the effect of a slowly moving weight applied many times (96,000), and the effect of a weight moving with velocity over a beam. The whole report represents an extraordinarily fine achievement for less than two years work, since it contains the first experiments on many subjects of vital importance to engineers. Except for Fairbairn's experiments on wrought-iron built-up girders in 1860–61, nothing of importance was published on the resistance of metals to repeated loadings until Wöhler's classical work in 1870.

INFLUENCE OF FOOD PLANTS ON SOCIAL STRUCTURE

DR. REDCLIFFE N. SALAMAN'S presidential address to Section H (Anthropology and Archæology) is concerned with the social repercussions in Britain of one of the latest food plants, namely, the potato; for man's first need is food, and its character and acquisition largely determine his way of life.

The potato reached Spain about 1570 and the British Isles during the last decade of the sixteenth century. For the next hundred years in the south and midlands of England it remained a luxury raised in the kitchen gardens of the great houses. In the north its advance was more rapid and deployed over a broader social base. This difference was in the main due to the absence of the open field and the greater economic freedom of the workers in the north, created by competition between agricultural and mining interests. From about 1700 onwards the potato was eaten because it was liked, not because it was necessary.

In the south and midlands the cultivation of the potato was much slower and followed a different course. In general, the working classes ignored it. About 1725, market gardens sprang up outside London and the middle classes became interested in the new food. In 1778 the London retail price was ½*d.* a lb., or one-eighth the price of meat. In 1939 it was one-eighteenth, which partly explains why the tuber was not adopted earlier by the lower-paid town workers.

After the turn of the eighteenth century, farmer and labourer began to take an interest in the potato, first feeding it to their pigs and horses, and only when it was obvious that it did not poison them was it included in their dietary. On the evidence of Arthur Young, so late as 1784, the potato had made little progress in the homes of the rural workers. Prior to 1750, workers had been satisfied with a mixed wheat and barley or rye and barley loaf, while the well-to-do enjoyed a white wheaten one. A change gradually took place; the brown loaf was discarded and with it the social implication following the use of two standards in respect to the staple of life.

War and the disastrous harvests of 1794 and 1795 caused the price of the quartern loaf to rise in twelve months from 7*d.* to 1*s.* 1*d.*, and later to reach 1*s.* 5*d.* Wages showed no appreciable rise for some time and never fully covered the rise in the cost of living. In 1770 the average worker's daily wage could purchase two loaves, in 1780 one and a half, in 1800 four-fifths of a loaf, and in 1810 a whole one; not until 1850 could it acquire the same amount of bread as it had in 1770. To meet the crisis workers were invited to return to the mixed loaf or accept a potato and wheaten loaf; both were refused. After great privation, a compromise was found by the adoption of the potato as a major article of diet. The economic effect was deplorable. The cost of living was lowered and wages stabilized at the lowest possible standard. Other factors undoubtedly helped to make the lives of the workers so incredibly sordid during the first half of the nineteenth century, but none was more insidious than the potato.

The influence of the potato in England is the merest reflexion of that it wielded in Ireland. Its arrival coincided with the later stages of a long and devastating war. To a starving peasantry, literally without home or property, came this heaven-sent food. As easy to grow as to hide from the military, satisfying and palatable, its future was never in doubt. Probably in little less than a century it was the native Irishman's main, and sometimes his sole, source of food. Such a dominance is almost unique in man's long history. By fostering unlimited procreation, the potato decontrolled the size of the family, dictated the routine of work, the tenure and use of the land, and the amenities of the home. A monophagous peasantry with the lowest standard of living in Europe afforded unlimited scope for exploitation, socially, politically and industrially. The opportunity was not neglected in eighteenth-century Britain.

In the nineteenth century, when a far better understanding existed between the two countries, the destruction by blight of the potato crops in 1845 and 1846 led to a disaster without parallel until recent days. Nevertheless, so firmly established was the habit that, in relation to the size of the population,

the acreage under potatoes actually increased in the post-famine years. The history of the Irish people is in no small degree that of its subjection to a potato dietary.

HORMONES OF THE DIGESTIVE TRACT

A BRIEF summary of the chief discoveries which have led up to our present knowledge of the intrinsic hormones of the digestive tract is outlined by Prof. R. J. Brocklehurst in his presidential address to Section I (Physiology). This system of local hormones, all probably related to proteins, found in the upper part of the abdominal portion of the alimentary tract, is unique in that the active substances, released from certain parts of the tract, act on digestive organs in the near neighbourhood, without apparently having effects on remote parts of the body, such as occurs with the hormones secreted by the endocrine glands. So far as is known, the alimentary tract hormones are not discharged into the blood as a result of nerve stimulation; most of them are released as a result of the contact of substances in the gastric or intestinal contents with the mucous membrane, and the prolonged effects which they produce are limited to the period of such contact. There is evidence that some, at least, of them are destroyed fairly rapidly in the blood.

The elucidation of these hormonal mechanisms has been carried out in the main with the help of ingenious operative procedures specially designed to demonstrate the responses of particular organs, freed, so far as possible, from complicating factors such as their nerve supply. These procedures have included the formation of pouches of the two main parts of the stomach, fistulæ of the small intestine, the transplantation of pouches and glands to subcutaneous sites where they obtain a new blood supply, and the technique of cross-circulation.

Three humoral factors are concerned in gastric digestion. Gastrin is a substance which is released from the mucous membrane of the pyloric part of the stomach when certain food substances come into contact with it; it travels by the blood-stream to the body of the stomach and there stimulates the secretion of acid gastric juice. Much research has been carried out with the purpose of deciding whether gastrin is the same as histamine, a powerful acid-secreting stimulant known to be present in the stomach; but, as active gastrin preparations containing no appreciable quantity of histamine have been prepared, it now seems likely that they are separate substances. A second humoral stimulant of gastric secretion is a substance liberated from the mucous membrane of the small intestine when the contents of the stomach pass into the latter. Little is known about its nature.

Gastric digestion is retarded by a substance, enterogastrone, which is liberated when fats enter the small intestine and which has an inhibitory action on both gastric secretion and gastric motility. There is a definite possibility that these activities may be due to two distinct substances.

The secretion of pancreatic juice is stimulated by a double hormone mechanism. Secretin, the first alimentary hormone to be discovered and investigated, is discharged into the blood when dilute acid, bile salts or certain other substances come into contact with the mucous membrane of the duodenum and upper small intestine. It evokes a secretion which is mainly an aqueous solution of bicarbonate and which has a low enzyme content. It is an important link in the self-regulating process whereby the hydrogen-ion concentration of the former gastric contents becomes reduced to a level suitable for the action of the pancreatic enzymes. The hormone can be extracted in greatest amounts from the duodenal mucosa, and in decreasing quantities as the small intestine is followed downwards. Secretin preparations are now in use on human patients for diagnostic purposes.

The enzyme output from the pancreas is markedly stimulated by a second hormone, pancreozymin, from the same source, which itself has no influence on the volume of the juice secreted. By these two means pancreatic juice, complete with its enzymes and bicarbonate, is produced when chyme enters the small intestine from the stomach.

Secretin also stimulates the rate of bile secretion by the liver, though not so effectively as bile salts. A closely related hormone, cholecystokinin, also promotes the entry of bile into the small intestine by raising the tone of the gall-bladder muscle. It is discharged into the blood when fats reach the duodenum and is an important factor in indirectly facilitating the digestion and absorption of fats.

There is evidence that intrinsic hormone mechanisms play a part in the stimulation of the glands of the small intestine, and so are partly responsible for the secretion of the succus entericus. The evidence at present suggests that there may be two such hormones, one of which acts specifically on Brunner's glands in the duodenum. It has also been claimed that another intestinal hormone is concerned with the muscular activity of the small intestine villi.

HUMAN AFFAIRS AND THE PSYCHOLOGICAL POINT OF VIEW

THE point of view of a science, as Dr. J. C. Flugel indicates in his presidential address to Section J (Psychology), has some significance apart from the knowledge that has resulted from the practice of the science: the scientific point of view depends upon the adoption of a predominantly cognitive attitude or 'set' in which wishful or 'autistic' thinking is rigorously subordinated to the search for truth; the different sciences result from the adoption of this point of view with regard to different, more or less arbitrarily distinguished, categories of phenomena. Psychology results from its adoption towards the phenomena of 'mind' and of 'behaviour'—a field where this adoption has some special significance in virtue of the fact that here, even more than elsewhere, we are liable to be influenced by emotional and moral considerations rather than by objective cognitive judgment. The full significance of the psychological point of view can best be realized when we consider the impact of psychology on certain other disciplines and the conflicts between the contrasting points of view involved in such cases.

Psychology split off from philosophy very largely on account of the adoption of the empirical method of systematic observation and experiment which it endeavours to take over from the physical sciences. As a consequence of this, in its modern developments

it has stressed the affective and 'orectic' aspects of mind more than the purely intellectual processes of knowing which were of chief interest to the philosopher. In this way, in describing the actual processes of thought, it has in turn corrected the over-intellectualistic approach in the older treatises on logic. The old problem of determination it short-circuits by accepting motive, choice, decision, etc., as subjects which can be studied by the methods generally applicable to the inorganic sphere.

Medicine is another parent discipline from which psychology has sprung. Here the conflict lies chiefly with the materialistic point of view, though in modern psychosomatic medicine mind and body are treated on an equal footing. A greater realization, however, of the fact that many of the ills of the mind are no more under direct voluntary control than are the disorders of the body would produce a great alleviation of shame and encourage earlier resort to psychotherapy when it might be most effective.

There is much room for a closer psychological approach to economics, where the processes of saving and spending urgently call for a study of motivation on lines which, applied to production, are proving of great value in industrial psychology. In education psychology is already well established, but the increasing penetration of the psychologist into the field of delinquency has revealed a very significant conflict with the legal and moral points of view; and the latter conflict also plays its part in the relation between psychology and ethics, where the old problem as to whether values are subjective or objective has been rendered more acute by psychological studies of the processes of moral development and moral evaluation. Somewhat similar problems have been raised by the psychological approach to æsthetics, though the conflict is perhaps still more acute as regards religion, where the psychological investigation of the religious attitude and its development has appeared to constitute a threat to theological beliefs, although, at the same time, psychology has itself corroborated the great significance of the affective factors that enter into religion. Perhaps the most urgent need for a greater adoption of the psychological point of view is in the field of politics, where existing 'social psychology' has as yet had little actual contact with grim political realities, although psychological studies of some of the mechanisms at work—for example, ambivalence, displacement of affect, projection, splitting—certainly merit more attention than they have received from those who control the destinies of people.

Finally, as regards man's use of energy, which is the main topic of this meeting of the British Association, the human direction of physical energy depends ultimately upon man's use of the energies in his own mind, and it is only psychology which can teach him the nature of these energies and the methods possible for their direction. Hence, a very grave responsibility rests on the psychologist.

MODERN TRENDS IN THE CLASSIFICATION OF PLANTS

DR. W. B. TURRILL'S presidential address to Section K (Botany) reviews briefly some reasons for the relative neglect of plant systematics in recent times, particularly in universities. Taxonomists have tended to be too rigid in principles and methods; the rise of other branches of botany has captured the imagination of students; the subject is not easy to teach adequately; and there has developed the vicious circle of few or no teachers and few students with a bent towards systematics. There are signs that the position is changing. Gross morphology still provides the main basis for classification of the approximately 250,000 species forming the seed-bearing flora of the world; but methods of collecting, of analysis, and of description have improved and recent monographs and floras illustrate these improvements. Still more important has been the introduction into taxonomy of data, methods, and principles from other branches of biology, which may lead from classifications based on superficial characters towards an ideal classification which shall bring together all possible knowledge of plant life. The impact of the new points of view is considered in some detail.

Anatomical structure, particularly at the family-level, is correlated to a high degree with gross morphology. The recently published work by Metcalfe and Chalk, "The Anatomy of the Dicotyledons", provides much new information. Similarly, the biochemistry of plants often provides taxonomic data from the occurrence of volatile oils, alkaloids, glycerides and other chemical products. Cytological data can throw much light on taxonomic problems, especially at about the species-level, by providing additional characters and by indicating with greater or less certainty the origin of this or that taxon. Some new problems have, however, to be faced by taxonomists as the result of cytological investigations. They have, for example to consider the treatment of polyploids within what has been considered a species unit. From ecology, taxonomists can expect help in delimiting stable units. Aut-ecological studies are of great importance, and experimental ecology by such studies as those of the transplant experiments at Poltern and Kew, in California, and elsewhere, have already yielded valuable new facts for classification. Genetical research must be more closely linked with taxonomic studies if both are to progress satisfactorily. Long-range experiments with *Silene*, *Centaurea*, *Ranunculus*, and species of other genera show how genetical methods combined with those of taxonomy and ecology can solve many problems of systematics. Morphogenesis and organogenesis applied to taxonomic problems emphasize the value of considering full life-histories and past developments. Plant geography has to be based on taxonomy; but the mapping of ranges and distributions reciprocally helps with taxonomic difficulties. There is a great need of further research into the past history of the flowering plants by studies of fossils. Modern statistical methods are being gradually introduced into taxonomy; but special methods must be developed for problems peculiar to classification, and the taxonomists hope that statisticians will turn their attention to some of these.

Phylogenetic facts should be considered in preparing classifications; but most often general phylogenetic hypotheses have been based on classification, not vice versa. Recent papers by Sporne and Corner raise many questions regarding primitive and advanced characters and the course of evolution in the flowering plants. Entirely new methods and principles may yet be applied to plant classification. Hayata's so-called 'dynamic system', and the use of

figure and letter symbols in place of orthodox nomenclature, at least within the species, are suggestive.

Training in taxonomy is now receiving more serious attention. The best approach is to teach the student to teach himself the practice of taxonomy, and to guide him to an understanding of the fundamental principles of classification. This double approach must be unified: principles become dogmas unless constantly applied to, and tested by, facts; merely to collect facts is to make bricks without building. Teaching in systematics must be mainly by practice, and the newer methods and outlooks considered in this address should be given prominence.

The potentialities of plant taxonomy are very great. Without classification no research is possible. Systematics is linked with all other branches of biology. Taxonomists desire to make their classifications more and more useful to all biologists. They work to serve and ask only for such recognition as they fairly deserve.

QUALITY IN AGRICULTURE

THE main theme of Prof. H. D. Kay's presidential address to Section M (Agriculture) is that the maintenance of a tolerable standard of living in Great Britain in the future will depend to an increasingly large extent on the quantity and quality of food that can be obtained from the limited home acreage. Though there is an appreciable area of poorer marginal land which, using modern methods of reclamation, could be brought into cultivation (though at considerable expense), it is clear that much more food per acre must be produced from the better land now being farmed. The average quality of British farming is far from poor; but there is still a considerable margin for improvement on most farms.

The official approach to this major problem—the important Agriculture Act of 1947 and the agricultural expansion programme of the same year—called for improved quantity and quality of products, and laid emphasis on better farm management and adequate application on the farm of the results of scientific and technological research. The agricultural expansion programme is an endeavour to meet the economic rather than the military vulnerability of Great Britain. It is a challenge, not so much to agricultural science as such, but to the science of getting existing knowledge applied as rapidly as possible to increasing the productivity of the large majority of the relatively small units of an inherently conservative industry.

The assessment of British farming quality and efficiency in terms of monetary values and profits has of recent years, in view of subsidies, other artificial fluctuations in financial returns and arbitrary changes in rates of exchange, lost much of its significance. Efficiency must now be measured in other terms. Production per acre of foodstuff of adequate quality, when compared against local or national standards of good husbandry, gives the basis for a better estimate, and one more in line with national needs, of the quality of the work of any given farmer, or group of farmers, and provides a standard for emulative effort.

Milk production is by far the most important of agricultural enterprises in Britain. At present, by whatever yardstick it is measured, production efficiency varies very greatly from farm to farm. It is now possible to propose reasonably quantitative standards for assessment of quality in dairy farming. The average dairy farm in England and Wales, with a cow population of twelve to fourteen, should, by using modern scientific knowledge and up-to-date management methods, be able to carry double that population with no loss, but rather an increase, in yield per cow. This would allow, on such a farm, for one other competent worker as well as the farmer to be maintained and adequately paid. In an average year, such a farm could be made almost self-supporting, given the necessary fertilizers from without. In the product, good keeping quality, freedom from pathogens and high nutritional quality denote also the 'quality' dairy farmer. It is of particular importance to maintain high nutritional value of milk; payment for milk on compositional quality would assist in this desirable objective.

With the substantially increased yields of milk per cow and per acre that science has now placed within the grasp of the competent dairy farmer, the 2,000 million gallons of milk per year for the United Kingdom, which the nutritionist calls for to meet national minimum requirements for liquid milk consumption, could be produced from a very appreciably smaller acreage than is the 1,750 million gallons produced at present. A steady move in this direction, with a concentration of dairy cows into specialist herds, should progressively liberate more good-quality land both for the home-grown cereal expansion programme and for providing more and better quality beef and other animal products. Methods for improving the quantity and quality of pigs and poultry, using home-produced feeding-stuffs only, are now known, and new methods are being investigated. The possibility of producing fodder yeast in Colonial territories abroad for supplementing pig and poultry rations at home requires further consideration and large-scale experiment, which would be likely to benefit both home and Colonial economy.

In improving farming quality, one of the most important needs is to give the large and increasing number of scientifically and practically trained young agriculturists, who have, under present inflated price conditions, little or no prospect of being able either to purchase or rent a suitable holding, a real opportunity to farm for themselves. Modern farming demands to-day a high level of scientific training and practical skill in its entrants, and must become in fact, if not in name, a chartered profession for which the same careful and thorough preparation is required as for other nationally important professions. In future, some certificate of competence from a national registration authority should be required before a man (or a woman) is allowed to farm on any but a quite small scale. This principle has already been officially adopted for smallholders.

The most serious question in British agriculture to-day is how to introduce more rapidly into practice on the majority of farms the new knowledge that agricultural science has made available. Research is needed on the limiting factors which prevent the established results of agricultural research being sufficiently widely and effectively applied. The greater the extent to which, during the very near future, these recent findings of science can be applied to the general improvement of farming quality, the less hard will it go with the nation when the highly artificial and somewhat inglorious receipt of aid from abroad comes to an end.

ENERGY IN THE SERVICE OF MAN

EXHIBITION AT BIRMINGHAM

IN connexion with the annual meeting of the British Association an exhibition has been arranged at the University of Birmingham to illustrate the topic "Energy in the Service of Man" suggested by Unesco for world-wide discussion and study in 1950. The exhibition has been sponsored by the National Coal Board, the Gas Council and the British Electricity Authority in conjunction with the Birmingham City Museum and Art Gallery and the Birmingham Common Good Trust, and is staged in the Mechanical Engineering Department of the University at Edgbaston. It was open to the public during August 21–29 and will be open again during September 7–9 after members of the British Association have had the opportunity of visiting it during the period of the meeting.

It is fitting that such an exhibition should be held in Birmingham, which owes its rapid development to the early exploitation of industrial power following the inventions of that small group of men who made the industrial revolution possible. The first section of the exhibition pays tribute to the work of these inventors, many of whom had close connexions with Birmingham; drawings, letters and memoranda from the Boulton and Watt collection are on display, with William Murdock's note-book and a calculation book of James Watt, alongside working models of early steam engines. The original engine constructed by Murdock in 1784 and the first electroplating machine patented in 1842 by John Stephen Woolrich, a Birmingham chemist, are notable exhibits.

Coal is the main source of energy in Great Britain, and the formation of a coalfield from forest debris is illustrated in a series of coloured plates showing various stages in the process. A selection of fossil remains of Coal Measure plants accompanies this exhibit.

The development of mining methods during the past two hundred and fifty years is shown by a series of diagrams and models. The horse whim and various types of gin used for raising coal before the invention of steam engines contrast markedly with modern examples of mechanization, and the hazardous nature of early mining operations is exemplified by a model demonstrating a method of setting off underground gas accumulations by the use of a naked flame. Sectional models illustrate the principles of 'room and pillar' and of 'longwall' methods of mining, and new developments in coal cutting are represented by working models of the hydraulically operated Samson stripper, which shears off the coal face and ploughs it on to a conveyor as it advances, and by the Meco-Moore cutter loader. A full-scale modern coal cutter is shown working along a portion of a longwall face.

Coal coming from the pit contains shale and other impurities, and as thinner and deeper seams are mined, and as mechanization increases, so does the amount of dirt. Coal cleaning thus becomes of great importance, and the principles of a dense-medium coal-washing plant are indicated by a model in which the coal is shown floating in a medium of specific gravity greater than that of coal but less than that of the dirt, which sinks and is removed.

Coal utilization is excellently portrayed, and a number of diagrams show the numerous by-products of coal carbonization. Sectional diagrams of a typical combination underjet coke oven and of a modern continuous vertical-retort setting indicate the principal methods of high-temperature carbonization employed at the present time; flow diagrams and a working model of a gasworks provide further information. The extraction of benzole from coal gas as practised in the gas industry is described by an attractive flow diagram, and the cycle of operations of an automatic carburetted water-gas plant is realistically reproduced by another model.

The downjet-combustion of coke is described and methods of testing this solid fuel are shown.

Refractory materials are widely employed in the gas industry, and a series of well-chosen exhibits show methods of testing these materials and their deterioration in use.

The removal of tar fog from coal-gas by electro-detarrers is now a common procedure at gasworks. This process resulted directly from the work of Sir Oliver Lodge (the first principal of the University of Birmingham) and of Dr. F. G. Cottrell in the United States, and an effective demonstration of electrical precipitation is included in the exhibition.

A series of photographs illustrates recent investigations by the Gas Research Board and the use of modern scientific instruments in the gas industry.

Waste-heat recovery is a topic of considerable interest to the gas engineer, for the flue gases leave retort settings at about 900° C., and by passing these through waste-heat boilers a considerable saving in fuel can be effected. As an alternative procedure, a 700-kW. closed-cycle gas turbine is to be installed at a West Midlands gas works; a model of this unit is displayed at the exhibition.

A selection of modern gas burners and an illustration of gas distribution methods complete the gas section.

The British Electricity Authority is at present building thirty-eight new power stations and installing new plant at forty-three existing ones. The generation of electric power and new developments are illustrated at the exhibition by a number of well-chosen models and demonstrations, including sectional models of the generating station at Staythorpe and of a typical hydrogen-cooled turbo-alternator. A particularly interesting exhibit is a model of the Metropolitan-Vickers 15,000-kW. gas turbo-alternator designed for the Trafford Park station of the British Electricity Authority.

Water cooling presents a considerable problem at power stations, and working models of cooling towers are on view.

The recovery of a valuable element from a waste product is depicted in this section of the exhibition. It has been known for a number of years that the flue-dusts from boilers and gas producers contain small amounts of germanium, gallium and other rare elements, and it has been found that certain coals from the Northumberland and Durham coalfield yield up to 0·001 per cent of germanium. The extraction of this element is now undertaken commercially from flue-dust because of its valuable properties as a semi-conductor. Germanium diodes and triodes are displayed alongside samples from various stages in the extraction of the element.

A novel exhibit is the fuel cell constructed by the British Coal Utilization Research Association. The prospect of developing electrical energy directly has for long attracted the attention of investigators, but no fuel cell has yet proved completely successful.

Demonstrations of electrolytic polishing and of tests on a television receiver lend interest to this section, and further exhibits deal with the transmission of electric power and its use in the electric arc furnace employed in alloy steel manufacture.

The visitor leaving the exhibition is faced by a small pellet of uranium with an accompanying notice which reminds him that quick results should not be expected from work now in progress directed towards the use of atomic energy for power production. Design studies and cost estimates for nuclear reactors will necessarily take a number of years to complete, before plans for full-scale nuclear power producers can be made.

In connexion with the exhibition, five public lectures have been delivered at the Midland Institute, Birmingham, by Mr. W. V. C. Gale, Mr. James R. Beard, Dr. A. Parker and Prof. F. H. Garner, and on September 5 Sir Alfred Egerton will deliver a concluding lecture on "Civilization and the Use of Energy". Films are being shown daily while the exhibition is open.

The exhibition has been extremely well planned, and the exhibits are displayed effectively against a modern background which by its simplicity does nothing to distract the attention. The organisers are to be congratulated upon the arrangements adopted, and the exhibition deserves to be well attended.

A separate exhibition dealing with oil fuels is being shown to members of the Association in the University's Chemical Engineering Department.

NEWS and VIEWS

Civil Engineering at Birmingham : Prof. C. Batho

Prof. Cyril Batho, who retires in September, has occupied the chair of civil engineering in the University of Birmingham since 1924. Educated at the University of Liverpool, he later studied at Berlin and Charlottenburg and in 1908 was appointed lecturer in civil engineering, and in 1911 assistant professor, at McGill University. During 1912–13 he acted as design engineer on the New Quebec Bridge, and in the following years published a number of papers on the stresses in structural members and connexions. After a period at the Royal Aircraft Establishment during the First World War, he became for a short time a lecturer at Trinity College, Cambridge, and in 1919 was appointed associate professor of applied mechanics and hydraulics at McGill University, where he remained until 1924. Prof. Batho was chairman of the Midland Association of Civil Engineers during 1932–34. As a member of the Steel Structures Research Committee he was responsible for a series of important investigations, the results of which appeared in reports of the Committee published in 1931, 1934 and 1936. He served also on a committee of the Institution of Civil Engineers which reported in 1938 on concrete containers for the storage of liquids, and, for a number of years, was engaged in research on reinforced concrete structures, a subject on which he published several papers. Since the termination of the Second World War he has directed a series of investigations supported by the Aluminium Development Association and related to the design of large structures in light alloys. Although Prof. Batho's main interests were concerned with statically indeterminate structures and with riveted and other connexions, his work has covered a range of subjects, including creep in concrete and torsional stresses in thin-walled prisms. He has also wide interests in music, literature and the arts, which have led him on numerous journeys to Continental centres. His excellent lectures, illumined by a ready humour, will remain long in the memories of his students, and his colleagues will miss his wise and single-minded counsel in faculty and senate.

Dr. S. C. Redshaw

Dr. S. C. Redshaw, who has been appointed to succeed Prof. Batho, graduated at University College, Cardiff, in 1927 and took his Ph.D. in 1936. During 1927–32 he held posts in the aircraft industry. From 1933 until 1936 he was assistant lecturer in civil engineering at the City and Guilds College, Imperial College of Science and Technology, and acted as consultant to the British Aeroplane Co. In collaboration with Prof. A. J. S. Pippard he carried out research for Vickers (Aviation), Ltd., on geodetic construction. During 1936–40 he was scientific officer at the Building Research Station, where he specialized on research into the strength of bridges. In 1940 he was appointed chief airworthiness engineer and in 1945 chief engineer of Boulton Paul Aircraft, Ltd. In 1948 he became a director. As chief engineer he was responsible for all the technical work of the Company and for control of the design staff. His work has consisted of research and development in connexion with experimental methods of stress analysis, including model structural analysis, photoelastic and electrical analogue methods. The development of electronic methods of strain gauge measurements and the design of instruments for the automatic recording of strains and deflexions in flight also came under him. He is a member of the Mechanics Committee of the Aeronautical Research Council and of the Technical Board of the Society of British Aircraft Constructors. He is also president of the Birmingham branch of the Royal Aeronautical Society and vice-president of the Wolverhampton Engineering Society.

Botany at the British Museum (Natural History) : Dr. J. Ramsbottom, O.B.E.

After almost forty years' service, the last twenty as keeper of botany, Dr. J. Ramsbottom will retire from the British Museum (Natural History) in October. In this key position he has had a profound and beneficent influence on British botany. On going to the Museum he specialized in fungi and soon became one of the foremost mycologists with a special interest in the larger fungi. During his keepership he became interested in a number of learned societies and more especially in the British Mycological Society, one of the friendliest groups of biologists that has ever existed, which owes much of its intimate character to his influence. Outside Great Britain he has done much to foster international understanding by his active friendship with mycologists all over the world. Dr. Ramsbottom has always insisted on the importance of broadly based taxonomy, and his own taxonomic interests have extended

beyond the larger fungi to many groups of micro-fungi and especially to those of medical importance. With the sudden development of interest in antibiotics aroused during the Second World War by penicillin, his advice was of great importance, and he has rightly insisted that mycologists and not chemists are the proper people to be entrusted with the growth of moulds. His influence in mycological education has been great. By means of lectures and displays arranged in autumn at the Museum, he has aroused widespread interest in fungi and has been responsible for introducing many a student to mycology. He has made varied and valuable contributions to mycological literature. Nearly every naturalist who forays among the fungi has a well-worn copy of his "Handbook of the Larger Fungi"; his little book "Fungi" (published for sixpence by Benn in 1929) is one of the best introductions to mycology in existence; his presidential address to the Linnaean Society, "The Expanding Knowledge of Mycology since Linnæus", is a major contribution to the history of botany; and his two little King Penguin books, "Edible Fungi" and "Poisonous Fungi", have extended interest in these organisms throughout the length and breadth of Britain. On leaving the Museum, Dr. Ramsbottom by no means retires from mycology. Indeed, he remains one of the most active figures in British botany. His many friends the world over will wish him a long and happy retirement.

Dr. George Taylor

Dr. George Taylor has been appointed to succeed Dr. Ramsbottom. Dr. Taylor was born at Edinburgh on February 15, 1904, and was educated at George Heriot School, proceeding thence to the University of Edinburgh, where he had a successful academic career. Immediately after taking his degree he accompanied the late Reginald Cory and others on a horticultural collecting trip to South Africa. He entered the Department of Botany of the British Museum (Natural History) in 1928. His work was principally concerned with Gamopetalæ; but he continued with his monograph on the genus *Meconopsis*, which was published in book form in 1934. In 1934–35 he went as botanist to the British Museum Expedition to East Africa, and made extensive collections on Ruwenzori and other mountains of western Kenya. Another opportunity to study alpine flora came in 1938 when he was invited to accompany the well-known botanical collectors F. Ludlow and G. Sherriff on their expedition to Tibet. Most of the plants collected previously had been those likely to prove of horticultural interest, and, consequently, the fully representative sample of the flora which was obtained is extremely valuable. Unfortunately, before much could be done with it, war broke out and almost immediately Dr. Taylor was seconded to the Air Ministry with the rank of principal. He returned to the Museum in 1946 and was soon afterwards appointed deputy keeper. He is an active student of the British flora, particularly of the rarer plants of the mountains of Scotland. At another level he has worked at aquatic plants, chiefly Podostemaceæ, but also, in collaboration with J. E. Dandy, is monographing the British species of *Potamogeton*. Dr. Taylor is a keen gardener and has been active in the study of the horticultural possibilities of Himalayan plants. For many years he has been recorder of Section K (Botany) of the British Association.

Augusto Righi, For.Mem.R.S. (1850–1920)

A hundred years ago, on August 27 at Bologna, Augusto Righi, the Italian physicist, renowned for his researches in electricity, magnetism and light, was born. Most of Righi's life was spent in Bologna and he was professor of physics in the University from 1889 until his death on June 8, 1920. His earliest work was on the change of the electrical resistance of bismuth in a magnetic field, and he applied this phenomenon to the measurement of magnetic fields. He also studied the Kerr effect and found the variation in the plane of polarization with the wave-length of light. About 1880 Righi began a long series of researches on electric discharge *in vacuo* and in air, and this, in various forms, remained his main interest for the rest of his life. He observed the photo-electric discharge from a zinc plate on exposure to ultra-violet radiation and investigated the trajectories of cathode rays in a magnetic field; though the discovery of the electron eluded him, he was aware of the existence of negative carriers of electricity. Righi's name has been associated with a special form of Hertzian oscillator which is similar to the apparatus for the transmission of radio waves first used by Marconi, who knew of Righi's work but was never, as is sometimes erroneously supposed, one of his pupils (see Marconi's tribute in *Nature*, **105**, 526; 1920). Righi also wrote papers on the change of length due to magnetization, change of size in insulators under electric stress, and radioactivity. Of the many honours that were conferred upon him may be mentioned the 10,000-lire prize of the Academia dei Lincei and the Hughes Medal of the Royal Society. He was elected a foreign member of the Royal Society and of the Royal Academy of Sciences at Uppsala, and in 1905 was made a Senator of the Italian Parliament.

On the occasion of the centenary of the birth at Bologna of Augusto Righi, the Italian Physical Society is holding a congress there during September 15–20. A number of foreign physicists have been invited to participate. No specific programme has been prepared, and the various sessions of the congress will be arranged along the lines of the papers presented.

Royal Society of Canada: Annual Meeting

The annual meeting of the Royal Society of Canada was held at the Royal Military College, Kingston, Ontario, during June 5–7. Among the new officers elected for the year 1950–51 were: *President*, Dr. J. J. O'Neill; *Honorary Secretary*, Dr. Seraphin Marion; *Honorary Executive Secretary*, Dr. W. H. Cook; *President, Section* 3, Dr. H. G. Thode; *President, Section* 4, Dr. P. S. Warren; *President, Section* 5, Dr. L. C. Simard. The Flavelle Medal was awarded to Dr. C. H. Best, the Lorne Pierce Medal to Dr. M. Barbeau, and the Tyrrell Medal to Dr. J. B. Brebner (Columbia University, New York). Twenty-two new Fellows were elected to the Society. During the course of the meeting various symposia were held, one under the auspices of the Society entitled "The Arctic", one under Section 3 on "The Atmosphere of the Stars and Planets", and a third, under Section 5, on "Biological Macromolecules". Dr. J. A. Pearce, the retiring president, addressed the Society on modern concepts of the universe. Dr. T. L. Tanton, retiring president of Section 4, discussed "The Origin of Iron Range Rocks", and Dr. T. W. M. Cameron, retiring president of Section 5,

spoke on "Parasitology and Evolution". Dr. Cameron's paper considered evidence presented by certain groups of internal parasites on the evolution of their hosts and suggested, *inter alia*, a separate origin for the South American and Australian marsupials. It is also suggested in the paper that Africa and South America must have been joined in early Tertiary times, but that no connexion between those two continents and Australia need be postulated by the parasitological evidence.

German Paint Industry

In a recent B.I.O.S. Survey of "The Paint Industry in Germany during the period 1939–1945" (Report No. 22; H.M. Stationery Office, 1950; 3*s*.), the authors, Messrs. N. F. Fisk and H. W. Bowron, have collated and classified material relating to the paint industry from more than two hundred reports on German industry. Their survey is divided into four main divisions: (1) Paints, Varnishes and Printing Inks; (2) Waterpaints; (3) Cellulose Lacquers; and (4) Linoleum and Coated Fabrics. Among points brought out in the survey are the use of new pigments such as lead cyanamide, to which anti-corrosive properties were attributed, and chemically resistant silicon-containing pigments. As in other countries, much new work was done in Germany during the War in the field of synthetic resins such as acid-catalysed air-drying urea-aldehyde and phenol-aldehyde resins, the rapidly-hardening polyurethane combinations of diisocyanates with alkyd-type materials, and the extensively used aqueous emulsion coatings of polyvinyl acetate and polyacrylates. Acetylene was one basis of the German chemical industry, and in addition to being the source of the vinyl compounds, it was the starting material for tetrahydrofurane, a useful solvent for polyvinyl chloride. Another basic process was the Fischer–Tropsch synthesis of hydrocarbons from carbon monoxide and hydrogen. This also served the paint industry, because it provided a valuable supply of fatty acids and alcohols suitable for making plasticizing esters, and a fatty acid residue which was utilized in oil paints and waterpaints.

Blood-clotting and Allied Problems

The proceedings of the second Conference on Blood-Clotting and Allied Problems, held by the Josiah Macy Jr. Foundation in New York in January 1949, have now been published in a single volume (pp. 231; Josiah Macy Jr. Foundation, 565 Park Avenue, New York; 2.25 dollars). It contains articles on the separation and assay of a lipid antithromboplastin from human brain, blood, plasma and plasma fractions, on the chemical purification and mode of action of a thromboplastin inhibitor, on the standardization of thromboplastin, the structure of the fibrin clot and the mechanism of its formation, the surface effects on blood coagulation, zeta-potential studies, factors which influence the rate of conversion of prothrombin to thrombin, the blood platelets and coagulation and on a new synthetic anticoagulant (paritol). The discussions of these papers are also reported. An appendix describes the preparation and use of coloured and black-background lantern slides.

Christ's Hospital Science Journal and N.H.S. Report

It is with interest that we note the growing concern for science in schools, especially natural history, as evidenced by the increasing number of school science journals. Most of these, so far, are published by our public schools, the latest addition being the *Christ's Hospital Science Journal and N.H.S. Report*, the first number of which has recently appeared (No. 1, June 1950). The *Journal* contains several interesting articles, mainly by boys of the School. We note with regret, however, that only the ornithological section of the School Natural History Society has anything to report; this in a school so admirably situated for field studies is to be deplored. The *Journal* is to be welcomed, therefore, especially since its appearance might well not only record but also stimulate scientific field activities in the School. Copies of the *Journal* can be obtained from the Science School, Christ's Hospital, Horsham, Sussex, price 1*s*. 7*d*. including postage.

Colonial Service: Recent Appointments

The following appointments in the Colonial Service have recently been announced: S. D. Ross (assistant director of agriculture, Nigeria), director of agriculture, Gold Coast; W. E. Calton (government chemist, Zanzibar), government chemist, Tanganyika; A. Cawley (mining geologist, Nigeria), assistant director of geological surveys, Nigeria; D. W. MacGregor (veterinary officer, Nigeria), senior veterinary officer, Nigeria; L. P. Georghiades (statistical clerk, Medical and Health Department, Cyprus), statistics officer, Treasury, Cyprus; A. H. Millard (pharmaceutical chemist, Federation of Malaya), chief pharmaceutical chemist, Federation of Malaya; G. H. Swynnerton (senior game ranger, Tanganyika), game warden, Tanganyika; D. E. M. Marsh, assistant conservator of forests, Gold Coast; J. W. Cowie, geologist, Kenya; R. J. M. Gillies, veterinary officer, Northern Rhodesia; K. Nixon and A. G. Willder, veterinary officers, Nigeria; L. A. White farm manager, Department of Agriculture, British Guiana.

Announcements

The fourth Arthur Stanley Eddington Memorial Lecture will be given in London on November 2 by Prof. R. A. Fisher, Arthur Balfour professor of genetics in the University of Cambridge; he will speak on "Creative Aspects of Natural Law".

Mr. Reginald D. Meadows, demonstrator and supervisor in the School of Geography, University of Cambridge, has been appointed a lecturer in the Department of Education of the International Wool Secretariat. Mr. Meadows has specialized in the economic history of the woollen and worsted industries, and has travelled extensively abroad, where he had the opportunity of studying native sheep in North Africa, Malta, the Azores and Iceland. In Britain he has carried out a detailed survey of the early cloth industry of East Anglia.

A symposium on "Polymer Chemistry as Applied to Plastics" has been arranged by the Plastics and Polymer Group of the Society of Chemical Industry and will take place at Beveridge Hall, Senate House, University of London, during September 21–23. Details of the programme of papers have been published in the August 4 issue of *Chemistry and Industry*. Non-members of the Society may participate in the symposium. Further particulars may be obtained from the Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

SOCIAL AND SAMPLE SURVEYS FOR PLANNING AND ECONOMIC POLICIES

POLITICAL and Economic Planning is at present engaged on a major study into the whole field of the relations between government and industry, and the means by which the government gets its policy carried out. From this point of view of the ways of translating planning into practice, a recent broadsheet (No. 310) discussed the approach to planning and planning techniques so far as they are indicated in three recent books: Prof. W. Arthur Lewis's "Principles of Economic Planning"; Dr. T. Balogh's "The Dollar Crisis, Causes and Cure"; and the United Nations experts' report on "National and International Measures for Full Employment". The three books between them cover the greater part of the possible methods of translating planning principles into practice and indicate the current state of thought on the relation between the theory and practice of planning.

The first two were prepared for the Fabian Society; but whereas Dr. Balogh argues for selective controls which permit incentive to be given to progressive and efficient managements, Prof. Lewis regards planning through the market as the more flexible method. Only Prof. Lewis deals with the important point of mobility of reserves and labour in a full-employment policy, and his contribution is not sufficiently precise to be useful. All three books insist that the economy of a country cannot be planned in isolation from the rest of the world. The broadsheet, however, gives a comparative rather than a positive appraisal of the three approaches, reserving judgment until the factor involved in the psychological problem as well as that of organisation can be more accurately assessed.

Meanwhile, two further broadsheets dealing with one particular technique—the sample survey—have appeared (Nos. 313 and 314). The first of these examines the techniques used in such surveys to obtain facts about human activities and describes the recent work of the Government Social Survey and the use of sample surveys in market research. It emphasizes that the technique of sample surveys is not one for amateurs or untrained persons, and at present not all those who conduct sample surveys have the necessary knowledge and skill. The appropriate techniques vary widely, like the needs of users of sample surveys; and the limitations of the present methods can only be fully appreciated if the particular needs are considered separately.

In general, users must consider such questions as what degree of accuracy is required; whether detailed information and a correspondingly detailed interview are wanted; the extent to which informants are likely to be interested in the purpose of the interview, and the level of public co-operation needed to ensure successful interviews; the form of the question, record or observation that is appropriate to the problem in hand. When these questions have been answered, it can be decided what degree of skill will be required in the investigator, and whether a solution of the problem will involve detailed analysis and a high level of statistical competence in handling the results obtained. That is to say, what issues from a survey depends upon what is put into it; and, if the technique of sample surveys is not to be discredited, it is important, as the broadsheet rightly urges, that there should be a wider public understanding of the technical requirements for efficient surveys.

On the Government Social Survey, Political and Economic Planning concludes that this has proved an administrative tool of permanent value which provides a reliable and economical means of collecting facts needed both for policy-making and for assessing the effects of changes in policy on sections of the population. Nevertheless, it is doubtful whether government work benefits as much as it might from the existence of the Social Survey. In many branches of government activity decisions are either being made without previous assessment of the social facts, or withheld or delayed because it is believed erroneously that such facts are impossible to get. Decisions of the Ministry of Food are cited to illustrate this point, and it is also suggested that the nationalized industries should utilize the Social Survey.

The second broadsheet continues the review by discussing the use, and the criticisms of, public-opinion polls; the problems of readership surveys; how the British Broadcasting Corporation discovers the sizes and preferences of its audiences; and the uses of sample surveys in making special studies, particularly in the medical sphere, without the aid of permanent survey staffs. For success such surveys depend on the use of the services of workers skilled in other fields, and they are chiefly of value in enabling a wide field to be surveyed and profitable lines of inquiry to be determined for closer study. The broadsheet is careful not to exaggerate the importance of sampling methods and points out that too much importance can be attached to them. Some surveys may yield results directly useful in determining policy; others may only indicate the need for wide or more detailed research. The sample survey is no more than a rapid way of getting at the salient facts of a situation, and its advantage lies in the fact that it makes judgment freer by enabling it to concentrate immediately on the important issues.

Within these limits, Political and Economic Planning holds that the techniques of sample surveys are by no means fully developed, nor are the possibilities of present methods fully exploited. It is important that a professional spirit should develop among practitioners, and here the Market Research Society and the European Society for Opinion Surveys and Market Research could help. It is also suggested that the Government might provide the Social Survey with facilities enabling it to carry out the functions of a research organisation in the field of sample surveys. Survey reports also should be more widely available, and the possibilities offered by sampling methods should be made better known within the Civil Service. Warning is given against the use of departmental machinery when objective social results are needed. It is also suggested that a wider use of market research in industry at home might do much towards reducing costs, and that in overseas marketing full use of the facilities offered by the British Export Trade Research Organisation and like bodies would help to eliminate the 'hit and miss' methods which are all too characteristic of Britain's present overseas trading. Intelligently conducted public-opinion surveys could also show one half of the world what the other half thinks—and why—and could thus add something of real value to the general discussion of social and political issues which is a part of democratic organisation.

EDUCATION IN INDUSTRY

IN a paper presented to the summer meeting of the Association of Technical Institutions at Scarborough in June, Mr. T. H. Hawkins dealt with the industrial problems which had arisen out of part-time day release classes for young workers in industry. Part-time day release, he said, had been tried in practice and proved by experience and there was now no need to argue the cause for its necessity. Sufficient experience had been gained so that an assessment could be made from which the policy for future development could be elaborated.

Apart from the considerable difficulties of the administration of part-time day release classes, three main types of human difficulties arose. The first was from the point of view of young employees, many of whom cannot see why they should be forced, even for one day a week, to return to a place from which they had recently so mercifully escaped; some youths even prefer to stay at their jobs without pay to attending day release classes with pay. Since these adolescents are often the ones most requiring some supervision at a difficult time in their lives, Mr. Hawkins suggested that all classes should be of a compulsory nature.

From the management side the supposed antagonism of many industrialists towards part-time day release is often because they cannot see the link between general education and the young person's job in industry. They are ready to provide facilities for young people in their charge to attend classes of a technical nature; but cannot see what English or current affairs has to do with making boys or girls into better workers. Now that day release classes have been going some years, however, it is interesting that many managers have changed their minds about the value of these classes after seeing the beneficial effect they have on young people. Headmasters and teachers in part-time day release classes could do much to help departmental managers to see that part-time day release classes do connect with jobs by using many more illustrations than they do from local industries. In this connexion teachers could help themselves by being prepared to spend some of their vacations on training courses in different works.

From the industrial side the person who has most to do with the arrangement of part-time day release classes is the industrial education officer, and the particular difficulties which he sees are the way in which subjects are tackled in general education classes and the lack of suitable courses of a vocational nature for apprentice grades. In general education classes the more intelligent young people are dealt with quite adequately, although there is room for considerable experiment on how to deal with young people who are attending classes on one day a week only. With the less intelligent students, many of whom will have come from the lower classes of the secondary modern schools and may be near-illiterate, it is probable that subjects as such should be discontinued. The day release class teachers should work to an overall plan, but should be prepared to modify their daily programme according to the particular interest of the moment.

The industrial education officer is also concerned with the lack of suitable courses for apprentice craftsmen. Hitherto the emphasis in our technical institutions has been too much on providing suitable courses for the technician and not nearly enough on providing suitable courses for the craftsman. Recent suggestions for the upgrading of certain technical colleges and the launching of a Royal Institute of Technology may cause the craftsman to be even more overlooked and, as Mr. Hawkins pointed out, it should be always remembered that for every graduate in a works, there are about ten men for maintenance work of a routine character. Despite the comprehensive programmes prepared by the City and Guilds of London Institute, there are still no suitable courses for apprentice maintenance fitters, blacksmiths, pipe-fitters and other important maintenance crafts. The industrial education officer is also concerned because commercial apprentices cannot be deferred from National Service at the age of eighteen like other apprentices; on this point the Ministry of Labour and National Service shows a marked inability to adapt itself to changing needs and even to act in conformity with public utterances of Ministers like the President of the Board of Trade, who is continually stressing the need for an expansion of commercial staffs in industry. Mr. Hawkins also dealt with the difficulties caused by interference with production and the fact that the 1944 Education Act makes no reference to the question of who should pay the wages of students taking day release classes, as well as difficulties peculiar to certain industries.

CRYSTALLOGRAPHY IN SPAIN

THE official recognition in 1947 of the International Union of Crystallography was followed by the formation of national committees in a number of countries. The Consejo Superior de Investigaciones Cientificas appointed a Spanish National Committee in 1949, and announced its adherence to the International Union. This demonstrated to Spanish crystallographers the urgent necessity for the strengthening of contacts between the various laboratories and individual research workers within Spain itself. They decided, therefore, to form a Spanish Crystallographic Association, to include pure crystallographers and also chemists, physicists, engineers and others working with X-ray or electron diffraction methods.

The first meeting of the Asociacion Española de Cristalografia was held in Barcelona this summer during July 5–8. During the conference the following committee was appointed to hold office for the next two years: *President*, Prof. F. Pardillo; *Vice-President*, Dr. L. Rivoir; *Treasurer*, Prof. G. Martin Cardoso; *Secretary*, M. Abbad; and *Ordinary Member*, Dr. J. L. Amoros.

The proceedings included visits to the Crystallographic Laboratory in the University of Barcelona, and to the Museum of Mineralogy and Geology, established in the fine buildings originally used for a national exhibition. There was an excursion to the Montserrat range; this was only an interlude, however, in the more serious business of the day, which was a visit to the salt mine at Cardona, now worked mainly for potassium chloride. The scientific proceedings included two evening lectures given in English by Prof. K. Lonsdale, who had been invited to attend from Great Britain by the Consejo Superior de Investigaciones Cientificas and by the Association. These were on "Neutron Diffraction" and on "Thermal

Movements in Crystals", and were followed by considerable discussion. An afternoon lecture was given by Dr. Rivoir, on "Photometric Measurements in X-ray Analysis". He emphasized the importance of high-resolution photometric methods for the measurement of low contrast on photographic films and described work done in this connexion in the Instituto Alonso de Santa Crux, Madrid. Twenty-one papers were presented to the conference, but owing to limitation of time not all of these were read. The conference closed with a formal luncheon at the University.

The Crystallographic Laboratory in the University of Barcelona is well equipped both for classical crystallographical and optical measurements and for modern X-ray structural research, including the latest business-machine computational methods. Special mention should be made of the X-ray moving-film diffraction cameras designed by Dr. Amoros (for the equi-cone de Jong-Bowman and Weissenberg methods) which have been constructed in the Instituto Torres Quevedo (applied physics), Madrid. A compact slide-rule for structure-factor calculations designed and constructed by Dr. M. Font-Altaba was shown. This is able to multiply together the atom factor and an expression of the type

$$\binom{\sin}{\cos} 2\pi hx/a \binom{\sin}{\cos} 2\pi ky/b \binom{\sin}{\cos} 2\pi lz/c,$$

and to achieve an accuracy of more than 99 per cent. At the suggestion of Mr. Abbad, a circular slide-rule of a similar type is now being prepared.

Research work is now in progress in Spain, with financial support from the Consejo Superior de Investigaciones Cientificas, on many theoretical and practical problems, although there is not, at present, much technological application of X-ray crystallographical methods in industry. The emphasis is rather on pure research. At the conference, J. Garrido described a new way of interpreting Patterson syntheses which he called the "method of differences". This led to a discussion on the use and limitation of the Patterson method. In a paper by M. Abbad, Sta V. Gomis and S. Garcia on the crystal structure of $BaS_2O_6.2H_2O$, emphasis was placed on the fact that 'pseudo-extinctions' could be used to determine the heavy-atom co-ordinates more simply than by the Patterson projection which confirmed the results.

J. Amoros gave an account of some of the techniques he had seen used during a recent visit to Great Britain, and he also described the progress of his own researches on the structure of *l*-glutamic acid hydrochloride, using a trial-and-error method based entirely on Fourier syntheses, on a comparison of Spanish asbestos and chrysotile with about a hundred specimens from other parts of the world (with F. Pardillo) and on the ionic refraction of alums and of the Tutton salts. He has found that the presence of small, highly charged ions causes a marked depression of the refractivity. M. Font-Altaba described the use of his structure-factor slide-rule and also reported progress in structure determinations for saccharine and its metal derivatives. J. M. Font has made crystallographic studies of cerusite from Vallirana (Barcelona) and X-ray analyses of bauxites from north-east Spain. L. Rivoir showed Laue photographs of bent aluminium crystals with a discontinuous band structure in the reflexions instead of a continuous asterism. This discontinuous asterism disappears completely on straightening the crystal. L. Rivoir and S. Martinez Carreras have also studied thallium perchlorate by the powder method and have shown it to be isomorphous with thallium perbromate and potassium perbromate, but not with potassium perchlorate. G. Martin Cardoso gave a paper on the crystallographic study of diaspore as an intergrowth on andalusite. He also outlined the intention of the Association, which will meet regularly twice a year, to publish in Spanish a crystallographic bibliography, in the preparation of which members were invited to co-operate.

J. L. Amoros
K. Lonsdale

AFFINITY AND REACTIVITY OF ANGIOSPERMS TO *PHYTOPHTHORA INFESTANS*

By K. O. MÜLLER

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FORMER literature[1] has indicated that the *Phytophthora*-resistance of the '*W*' varieties, discovered by me in 1923, is controlled by a gene that is not present in the common European varieties. This resistance is caused by the increased reactivity or the 'hypersensitivity' of the host cells which have been penetrated by a parabiontic strain of the parasite[2,3]. The phenotypical effect of this gene is therefore chiefly characterized by the extreme rapidity with which the affected cells collapse. Recent investigations have shown that in those genotypes possessing the highest degree of resistance, this collapse is effected within 7–8 hr., using potato sprouts and at a temperature of 22° C. Furthermore, there is associated with this rapid cell collapse a more or less intensive infiltration of the cell walls and cytoplasm by phlobaphene-like compounds which give the invaded tissues the well-known brownish colouring[4]. Finally, using tubers, it was experimentally proved that the reaction is unspecific. The tissue loses, in the course of this reaction with a parabiontic strain, its capacity to act as host for eusymbiontic strains of this fungus and for other bacterial and fungal parasites of the potato tuber[5].

We also found significant differences in the speed of the cell-collapse reaction of the different tissues within a genotype. In both resistant and susceptible genotypes this reaction proceeds most quickly in the young sprouts of the tubers and in the leaves of the plants. The cells of the inner parenchyma of the stems were usually found to react much more slowly. The reaction of the cells of the flower petals and the parenchyma of the tubers is very often so slow that the final stage in the reaction is not always completed. (The last two of the five stages which we can distinguish in the complete course of the reaction[3,4] very often do not take place in the susceptible genotypes because the infected cells die before these stages are reached.) Rapid reaction in the tubers and a slow reaction in the sprouts or leaves has never been observed in our material. These differences of reaction by the various tissues correspond to their ability to act as host to the invading parasite. They can be so great that in some genotypes the leaves are resistant whereas the parenchyma of the tubers behaves as if susceptible.

The close correlation between the reaction-speed and the degree of resistance was confirmed when other members of sub-section *Hyperbasarthrum* of the genus *Solanum* were investigated comparatively. This investigation covered mainly various forms of *S. demissum* and their hybrids with European potato varieties.

Besides the gene which controls the blight resistance in the '*W*' varieties, other genes also exert an influence on the reactivity to the different *Phytophthora* strains. Lehmann[6] and Black[7,8] have shown that only the species *Solanum demissum* possesses more than two different genes which are involved in the inheritance of the resistance to the different *Phytophthora* strains. Furthermore, we know that there are probably no plasmogenic differences which interfere with the action of these genes. This was proved in 1941–44 by investigating comparatively reciprocal crosses between *Solanum demissum* and *Solanum tuberosum* (unpublished). But the graduated 'virulence-resistance' relationship in one direction does not fully explain the situation. This became obvious when about fifteen years ago Müller[9] and Rœder[10] found that the '*T*'-strain of the parasite, highly virulent on all parts of the tomato plant, was unable to infect the '*W*' varieties. The '*S*' strain of the fungus, however, which is extremely virulent on the '*W*' varieties, cannot develop on the tomato leaves. This indicates a 'multidirectional' biological specialization.

The behaviour of the host plants when tomato is attacked by the '*S*' strain and '*W*' varieties by the '*T*' strain is also characterized by a heightened reaction velocity in the defence-reaction. This reaction has been described as that produced by the '*A*' strain of the fungus on the '*W*' varieties. It seems to be identical with regard to its morphological characteristics to that of '*W*' varieties in contact with a common strain of *Phytophthora*.

If we attempt to explain the above-mentioned facts on the basis of the formal principles which have been developed in human pathology concerning the nature of reactive immunity, they would be difficult to understand. On one hand we find extensive differentiation of the species *Phytophthora infestans* into numerous biologically specialized sub-races. (Up to 1944 I had collected thirty-one strains of *Phytophthora infestans*, all of which are differentiated by their different behaviour against the leaves *and* tubers of my test assortment.) Moreover, this differentiation is associated with constitutional differences in the host. On the other hand, the host organism repels the parasite with an unspecific reaction, and this seems to follow the same course in all possible parabiontic host–parasite combinations. If we adopt the reasoning prevalent in human pathology, one would seem to exclude the other. For then we should be obliged to assume that every constitutionally different host type possesses a more or less specific antibody system. It has been experimentally shown, however, that this is not so.

On the basis of experimental results with the '*W*' varieties, I tried to find a way out of this dilemma[9]. I made the supposition that the conspicuous persistence of the fungus-affected host cell in the eusymbiontic host–parasite combinations is due to a temporary metabolic 'concordance' between the two partners (*Konkordanz Hypothese*). In this case the metabolism of the parasite fits in with that of the host-cell. But, if there is such concordance in too small a degree, then the physiological unity of the affected host-cell breaks down rapidly with the simultaneous appearance of the unspecific 'phytoalexin' or 'phytoalexins', that is, substances which are developed or activated in the host tissues and act as 'antibodies' or 'antibiotics'. These phytoalexins prevent the continued penetration of the parasite into the host tissue. With regard to the unspecific character of the phytoalexin, I argued that the *sensitivity of the host cell* was the principle which determined the specific behaviour of the host to the parasite.

The influence of environmental conditions on the immunological behaviour of the host tissues was another important feature which enabled us to complete our conception of the nature of blight

Table 1. Reactivity of the affected Host Cells and the behaviour of *Phytophthora infestans* ('common' strain) in Solanaceous and non-Solanaceous Species (Temp.: 17–23° C.)

Host	Leaves	Parenchymatous tissue of stem	Petals	Parenchymatous tissue of fruit	Tubers or roots or bulbs	Remarks
Sol. tuberosum	+ to ± III	± III	± III	± III	± III*	* Some varieties exhibit greater or lesser reactivity
Sol. hybr. ('*W*' varieties)	++ I	++ to ± I to III	÷	± II*	+ to ± I to III	* Only one variety tested
Sol. demissum (certain varieties)	++ I	÷	÷	÷	+ II–III	
Sol. demissum × *Sol. tuberosum*	++ I	++ to ± I to III	÷	÷	++ to ± I to III	Only resistant hybrids
Sol. capsicastrum	—	± II–III	++ I	± III*	÷	* Young fruits: ++ I
Sol. lycopersicum	++ I to II	+ II–III	± III	± III	÷	
Petunia hybrida	± III*	± III	± III	÷	÷	* Wounded leaves
Datura stramonium	± III	± III	± III	± III	÷	
Lycium halimifolium	± III	÷	÷	÷	÷	Leaves from seedlings
Cucumis sativus	—	—	÷	++ II	—	
Lactuca sativa	++ I*	—	÷	÷	÷	* Leaves from seedlings
Dahlia var.	++ I*	÷	÷	÷	++ I	* " " "
Phaseolus multiflorus	++ I*	++ II	± III	++ II	÷	* " " "
Beta vulgaris	—	+ I	÷	÷	+ I	
*Brassica oleracea**	++ I**	+ I	± III	÷	÷	* Var. *Capitata et botrytis* ** Young leaves
Anemone japonica	—	—	++ I	÷	÷	
Allium cepa	—	÷	÷	÷	± III*	* Only occasional infection was observed

++: The first change of the host-cells (collapsing or developing the dark pigment) was observed 18 hours or less after the application of *Phytophthora* zoospores to the tissue.
+: The first change was observed within 48 hours but after the lapse of more than 18 hours.
±: The first change was observed later than 48 hours after incubation.
—: No reaction.
÷: Not tested.

I: The parasite is unable to progress from the point of infection; sporulation does not take place.
II: The parasite can only spread a little beyond the focus of infection; fructification absent or only a weak one.
III: The parasite spreads without restraint and fructifies luxuriously.
II–III: Behaviour of the parasite not constant; fluctuating between III and II.

resistance. Temperature and narcotics can so alter the reactivity of the host plant that susceptible genotypes exhibit the behaviour of resistant ones, and *vice versa*[11,12]. This led us to the opinion that, *potentially*, the susceptible genotypes were also capable of defence reaction. The low reaction-speed in the eusymbiontic host–parasite combinations did not permit the defence necrosis to develop with sufficient rapidity to prevent continued penetration by the parasite. But if this is so, then the gene or genes which control the reactivity to the different strains of *Phytophthora* would be similar in action to the realizators (genes that determine which of two alternatives will be realized) in sex-determination of dicœcious plants having separate sexual forms. We may therefore postulate a functional system corresponding to Correns's *A–G–Z* complex. Thus the possession of this functional system would be a necessary primary condition if the host plant is to react in any way against the parasite.

Even if we cannot draw a complete analogy between sexual determination and immunological behaviour (a fundamental difference exists in so far as the reaction norm of the potato, attacked by blight, depends not only on the genotype of the host, but also on the *modus operandi* of the parasite), the analogy seemed nevertheless sufficiently far-reaching so as to justify the experimental examination of the following working hypothesis: If the function of the 'resistance genes' is actually only that of determining when and with what velocity the unspecific defence necrosis occurs, then it is very probable that there is a basic functional system possessed not only by the potato and its allied species, but also by plants much further distant in the phylogenetic sense. Therefore, if the cells of the latter take up the blight fungus, we may expect that they will exhibit the same immunological behaviour as the '*W*' varieties or the resistant *Solanum tuberosum* × *S. demissum* hybrids. But if this is not so, we would have to postulate that in such cases a eusymbiontic host–parasite relationship is established, supposing that there is the right nutrient substrata for the parasite. Both would be according to the 'concordance hypothesis'.

The most important feature in carrying out these experimental investigations was to ensure that the parasite was brought into direct contact with the plasm of the host plant under examination. This was necessary because the absence of any reaction on the part of the host did not necessarily mean that there was no affinity between host plasm and parasite. For example, the mechanical structure of the individual cell walls would constitute a barrier to the parasite and prevent it from gaining any contact with the reactive plasm. Therefore, after inoculations, our observations under the microscope had to be continuous to enable us to determine whether any real biological contact was established between host and parasite.

Of the species which exhibited clear affinity to *Phytophthora infestans* listed in Table 1, nine do not belong to the Solanaceæ family. *After artificial inoculation with a common strain, they all showed reactions which were similar in all apparent characteristics to those observed in plants of the sub-section* Hyperbasarthrum *of the genus* Solanum. Like these, they exhibited varying degrees of 'sensitivity' to the blight fungus (measured according to reaction velocity), and many of them are phylogenetically far removed from the genus *Solanum*.

Even the monocotyledonous plant *Allium cepa* possesses tissues which not only can be infected by *Phytophthora*, but can also be used as a nutrient substrate sufficient to bring the fungus to fructification.

Table 1, however, also demonstrates another fact. There are distinct differences in the ability of the various organs of particular plants to serve as host for the parasite. The behaviour of *Phaseolus multiflorus* was studied in detail because the plasma constituents of this plant form an excellent nutrient substrate for *Phytophthora infestans*. All degrees of sensitivity were observed in this plant. The reaction of the inner skin which lines the cavities containing the bean seeds was particularly remarkable. Within sixteen hours of application of the *Phytophthora* zoospores (22° C.), a dark brown discoloration and a necrosis of the contacted host tissue appeared. This tissue reacted as sharply and as quickly to *Phytophthora* as sprouts from tubers of the '*W*' varieties (see accompanying illustration). The petals of *Phaseolus multiflorus*, however, reacted relatively slowly to the penetrating germ tubes of the *Phytophthora* zoospores. The weakness of the reaction in this case is accompanied by a surprisingly strong development of sporangiophores.

Using observations from Table 1, the material in Table 2 was produced to show the correlation between the reaction-speed of the host cells and the behaviour of the parasite. The correlation coefficient $+ 0{\cdot}7781 \pm 0{\cdot}0380$ is significant, so that in this heterogeneous collection of monocotyledous and dicotyledonous host plants we find the rule confirmed: The more rapid the necrotic reaction of the invaded cell, the greater is the resistance of the plant as a whole.

Our experiments also indicated another important feature. All unusual host plants used, such as *Phaseolus* and *Brassica*, behaved in the same manner irrespective of the *Phytophthora* strain inoculated, though these strains each exhibit a different behaviour on the '*W*' varieties, on *Solanum demissum* varieties and on *Solanum demissum* × *S. tuberosum* crosses.

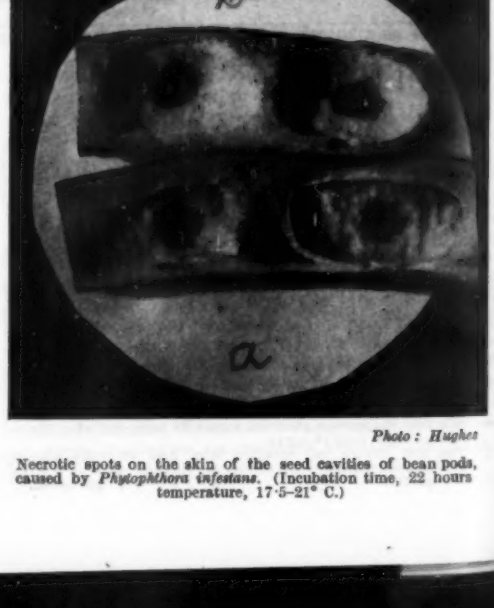

Photo: Hughes

Necrotic spots on the skin of the seed cavities of bean pods, caused by *Phytophthora infestans*. (Incubation time, 22 hours temperature, 17·5–21° C.)

This fact supports the suggestion that the hypothetical antibody which is activated or developed in the dying *Brassica* cells, as in the '*W*' varieties, is not specific.

We did not, however, succeed in inducing a reaction between strains of *Phytophthora infestans* and all the host plants that were inoculated. For example, we were unable to induce any reaction between the inner parenchyma of adult stems of *Sambucus niger* or *Rudbeckia* sp. (var. *hortensis*) and *Phythophthora*. The question in these cases is whether any affinity exists between the plasm of the host tissue and the parasite, or whether because of mechanical difficulties real contact between living host cells and the parasite did not take place.

However, these negative results do not affect the conclusion that affinity and reactivity to *Phytophthora infestans* are characters which may be possessed by many of the division Angiospermæ regardless of the phylogenetic position of the plants concerned.

Table 2. Correlation between the reaction-rate of the host-cells and the behaviour of the parasite

		Behaviour of the parasite			
		I	II	II–III	III
Reactivity of the affected tissue	++	13	4		
	+	4	1	1	
	±		1	2	23

Even though these experimental results appear to support our theoretical interpretation of the nature of *Phytophthora* resistance, it is possible that the same phenomena may have different causes, and different ones may have the same cause. It would therefore be premature to consider it proved that the defence necrosis in *Phaseolus* or *Brassica*, for example, is identical in all respects with that observed in the '*W*' varieties. But all observations of the course of reaction which follows the invasion by the parasite into the living cell indicate that the part of the metabolic system first affected by the invading parasite must be very common in Angiosperms. From the physiological point of view the specific 'sensitivity' of this functional system, controlled by significant genes, is the decisive factor for the reactive behaviour of the plant.

There is no doubt that the system first affected by the parasite is an enzymatic one and there are certain reasons (phenomenon of specificity, sensitivity to narcotics, connexion with the respiration metabolism and appearance of phenolic substances in the course of the defence reaction) that the system in question is connected or even identical with the dehydrogenase-system. Biochemical research must make clear whether this last suggestion corresponds to the facts.

Because cells of the susceptible plants possess a higher degree of persistence in the presence of the parasite than the resistant ones, we must conclude that a 'normal' parasitic relationship can only be realized when the speed of collapse of this system does not exceed a certain limit. If this limit is exceeded, then the necrotic reaction of the host-cell follows so quickly that the advance of the parasite is halted. That is not to say, however, that the graduated sensitivity is the only constitutional factor which determines whether a plant can become diseased by *Phytophthora infestans* or not. I am quite aware that certain other factors are involved. These experiments have shown that some of them work in complete independence of the reactivity of the plant. For example, the old leaves of *Petunia* with a low reaction-speed or those of *Nicotiana* are protected from the invasion of *Phytophthora* by the particular structure of their epidermis. In other cases the development of the parasite is determined by the suitability of a particular plant as a nutrient substrate. In plants with an intermediate reaction velocity relatively small quantitative differences would suffice to shift the balance of the ratio 'reaction-speed of host cells : development capacity of parasite' in favour of the host or of the parasite. It may also be possible that there are unspecific cell constituents of simple structure that exert an inhibiting influence on the parasite and alter the ratio in favour of the host. Nevertheless, it is quite clear from the facts we have considered that establishment of a normal parasitic relationship is dependent on relative tolerance or 'hyposensitivity' of the host plasm to the influences which are exerted by the invading blight fungus.

Furthermore, we conclude that the reactive *Phytophthora* resistance (or *vice versa*, susceptibility) is not a quality in the narrow sense of the word, as petal colour or leaf shape, but rather is a functional character which becomes efficient only when direct contact has been established between host and parasite. Therefore, that which is significant for the 'hyposensitive' blight-resisters is really not a gene for blight-resistance itself, but rather genes controlling a reaction potential, probably possessed not only by the genus *Solanum* but also by many other species of the division Angiospermæ.

Finally, I would like to direct attention to the relative character of the expression 'hypersensitivity'. Our experiments have shown that the affinity to *Phytophthora infestans* is not restricted to the genus *Solanum*. Moreover, we found that the hypersensitivity reactions seem to be the rule if we expand our considerations to the whole division Angiospermæ. 'Hyposensitivity' then seems to be the exceptional quality and not 'hypersensitivity'. So that if the term 'hypersensitivity' is used in the common sense, it must be remembered that its use is justified only when it is restricted to considerations of the behaviour of the genus *Solanum*. But regarding the reactivity of the whole division to which solanaceous plants belong we had to change our point of view. The exceptional behaviour is then represented by extremely 'hyposensitive' forms which seem to occur with frequency only in *Solanums*. Consequently, we had to designate the hypersensitive plants as 'normosensitive' ones.

I wish to acknowledge the help received from my colleague, Mr. J. Munro, of the National Institute of Agricultural Botany, Cambridge, in carrying out this work. I am also indebted to Miss M. Kostrowicka for technical assistance.

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STRUCTURE OF WOOL FIBRES

Isolation of an α- and β-Protein in Wool

By Dr. P. ALEXANDER and C. EARLAND
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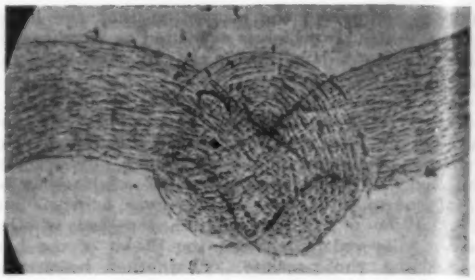
AQUEOUS solutions of peracetic acid oxidize the disulphide bond in wool to two sulphonic acid groups without attacking other major groups[1]. After more than 90 per cent of the cystine has been oxidized to cysteic acid, the wool becomes freely soluble in dilute alkali (for example, $N/10$ ammonia), except for a fraction representing 7–10 per cent of the total wool substance which remains insoluble[2]. Further treatment with peracetic acid has no influence on the solubility in alkali of this phase. The insoluble fraction is a continuous tubular membrane running the whole length of the fibre (see photograph); it is situated outside the cortical cells and forms part of the histologically highly complex cuticle of the wool[3], is readily filtered off, and on drying gives a pale yellow powder. 70 per cent of the protein which dissolved in ammonia was precipitated on acidification of the solution, and dried in a vacuum desiccator to give a white to pale yellow powder. This was freely soluble in dilute alkali giving highly viscous solutions which could be readily reprecipitated by the addition of further acid. The results given in the following communication show clearly that the insoluble phase has a β-keratin structure, while that of the soluble component has an X-ray diagram similar to that expected from a powder of α-keratin[4].

Using a solution of bisulphite and urea, Mercer[5] claims to have extracted from wool a small percentage of a gum capable of being drawn into a fibre giving an α-photograph. This result has been discussed by Happey[6], who suggested these possible alternative explanations of the phenomenon: either that the α-protein molecules were present as aggregates and were never in solution as single chains, and in consequence retained their specific α-form, or that single molecules regenerated from solution were capable of crystallization in the α-form. In this present work, however, the question of molecular aggregation and the α-structure tends to resolve itself, since the protein can be precipitated in the α-configuration from extremely dilute solutions in which any aggregates of molecules present in the original fibre are almost certain to have been dispersed. The major part of the soluble protein described here is electrophoretically homogeneous and has a molecular weight of approximately 70,000.

The α-fraction, besides dissolving in alkali, is also soluble in solvents capable of breaking the hydrogen bond, such as concentrated formic acid, which was studied in closer detail. On dilution with water, the protein is precipitated from the formic acid solution and the powder thus obtained is in the α-configuration. When the concentrated formic acid was removed by distillation *in vacuo*, the resulting protein was found to be in the β-form. The protein, when in the β-form, dissolves only very slowly in dilute alkali and swells much less than in the α-form. This suggests that there is more extensive interchain hydrogen-bonding in the β- than in the α-configuration.

This work has established that it is possible to retain or regenerate the wool molecules in the α-form from a solution of wool which has been solubilized by the oxidation of the disulphide bond only. It is interesting to note that the α-fold is not dependent upon orientation of the molecules in a fibre, that a specific biosynthesis appears not to be essential to its formation, and that the α- to β-transformation can be carried out without degradation by purely chemical means.



Insoluble β-membrane from a Lincoln wool fibre. × 80. (The fibre was knotted so as to demonstrate the continuity of the membrane)

After treatment with peracetic acid, during which the fibre contracts but does not dissolve, the bulk of the wool structure still remains in the α-form, as little change other than a loss of orientation was detected in the X-ray diagram of wool after this reaction[7]. It is likely, therefore, that the insoluble membrane is present in the original wool in the β-configuration. The only difficulty is that if it were present in such proportion (namely, 7–10 per cent) in a normal orientated crystalline form, then it should be capable of identification from an X-ray diagram of untreated wool. Microscopic investigations of the cuticle in whole fibres and of the membranes as isolated here show both to exhibit negligible birefringence, indicating an absence of orientation which was also observed by Woods[8] in the X-ray picture of isolated scales. The presence of the β-deflexion of 4·65 A. on the equator of the X-ray diagram may therefore be difficult to detect in wool because of disorientation or the presence of a mixed α- and β-structure in the cuticle. It is hoped to investigate this problem in detail at a later date. If this sheath of a tough β-keratin is present on the outside of the fibre, it may have some bearing on the action of anti-shrink processes. The abrasion resistance of decuticulated wool is also greatly decreased, and this would be readily explained if the tough β-keratin was removed during the process.

The morphological position of the membrane has yet to be determined unambiguously, but it appears to be situated[3] between the microscopically visible scales and the cortical cells. One would expect the elasticity of a β-cuticle to be less than that of an α-cortex, and this has been observed by Lehmann[9], who showed that the cuticle of a hair broke up after extensions exceeding 40 per cent. It is reasonable to ascribe the chemical resistance and insolubility of the membrane in part to the greater inter-chain hydrogen bonding possible in the β-configuration; but its insolubility in solvents capable of breaking hydrogen bonds, such as cupriethylenediamine or strong solutions of lithium bromide[3], which readily dissolve silk, suggests the presence of additional covalent cross-links which are not present in the fibre as a whole.

Preliminary analysis shows that the nitrogen content of the two fractions is the same as that of the original wool, but that the sulphur content of both is reduced from 3·6 to 1·4 per cent for the α- and 1·6 per cent for the β-fraction, and no disulphide sulphur can be detected. After the peracetic acid

treatment all cysteic acid formed by oxidation of the cystine is present in the wool, but most of this is associated with the low molecular-weight fractions which are not precipitated on addition of acid to the ammonia solutions.

From the physical changes produced by substances capable of breaking hydrogen bonds, Alexander[7] concluded that the fibrils of wool are made up of micelles which are joined to one another by disulphide cross-links, but that the molecules within the micelle are held by secondary valency forces only. The separation of wool without peptide-bond breakdown into fractions of different molecular weight and cystine content adds further support to this model. The low molecular-weight fraction rich in cystine may act as a cement between the micelles made up of the high molecular-weight protein which has a low cystine content.

In conclusion, it can be said that there is every reason to believe that the wool fibre is polyphase in structure, being comprised of at least two different structural components, namely, an α- and a β-protein. The β-phase forming part of the cuticle of the wool fibre is a tough skin which, from its chemical inactivity, can be considered as a protective membrane which surrounds and contains the main bulk of the fibre, an α-protein which is more readily susceptible to attack.

We wish to thank the directors of Wolsey, Ltd., for permission to publish this communication. It was thought that an X ray investigation would be relevant, but the specialized apparatus was not available in this laboratory. An advance copy of the relevant chemical data[2] was sent to Dr. F. Happey, who has now reported on the structural aspects of the problem. [April 25.

Note added in proof. Since writing this paper we have found that the soluble α-phase is capable of regeneration as an orientated fibre and gives an X-ray diagram very similar to that of the parent native wool. A detailed description of these experiments will be published in the near future.

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Polycrystalline Structure of Wool

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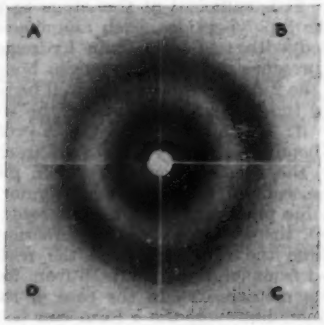
After treatment with peracetic acid, the protein of wool fibre can be divided into two fractions[1]: (*a*) the major portion of the fibre, which is soluble in weak alkali; and (*b*) a thin pellicle of protein which is continuous through the fibre in the form of a cylinder and which is insoluble in the above-mentioned alkali solvents. In all other respects, however, component (*b*) appears to have a chemical constitution similar to that of the bulk of the keratin fibre.

A precipitated sample of the soluble wool fraction and that of the insoluble protein pellicle are compared in the accompanying X-ray photograph and show



X-ray photograph of wool fraction after treatment with aqueous peracetic acid. Quadrants *A* and *C*, powder from insoluble membrane showing β-structure after extraction of wool with weak alkali. Quadrants *B* and *D*, soluble fraction precipitated from solution in the weak alkali and showing an α-type structure. Copper $K\alpha$ radiation; $D = 4$ cm.

very obvious differences of structure which can be summarized as follows: (*a*) the soluble keratin appears to be in the α-form, with a strong doublet of 10·5 A. and 9·5 A. and a ring at 5·2 A.; and (*b*) the insoluble fraction is in the β-form with a backbone spacing of 4·68 A. and a side-chain of 10·35 A.; as the X-ray diagram is obtained from a powder, it has not been possible to decide unequivocally at the present stage between a normal β- or 'cross-β-configuration', but it is felt that the former is the more probable.

Based on the work of Bamford, Hanby and Happey[2], a study was made of the solution and precipitation of the soluble wool product from formic acid, and the following observations were made. (1) The keratin dissolved in formic acid and precipitated by water gave a normal α-type diagram, and its solubility in weak alkali was unchanged. (2) When the formic acid was removed *in vacuo*, the protein gave a β-type X-ray diagram; it was comparatively insoluble in weak alkali.

Three points of the greatest importance with respect to protein structure in general and that of the wool fibre in particular emerge from this work. First, it is clear that on breaking the cystine cross-links in wool, the main bulk of the fibre is soluble in weak alkali. In this case the alkali solubility is facilitated by the formation of sulphonic acid groups which gives the wool fibre a higher acidity than is normally found. The soluble fractions of wool obtained by the method of Dr. R. L. Wormell and me[3], in which the cystine cross-linkages are broken by sodium sulphide with the formation of —SH groups, do not appear so readily soluble in alkaline media. Secondly, the presence of a pellicle of β-keratin associated with the surface scales of the wool fibre tends to raise further doubts as to the advisability of considering the crystalline part of the wool fibre solely as an α-protein, since at least 5 per cent of the material is not α-protein after treatment with peracetic acid and extraction with weak alkali. It is reasonable to suppose also that the insoluble pellicle was β-protein before this treatment was applied. If this is so, then it is likely that the crystalline β-keratin skin of the cuticle of the wool tends to enhance the unreactive nature of the fibre. In this connexion, the insolubility and comparative intractability under normal conditions of the crystalline β-form of the polypeptides has been demonstrated by Bamford, Hanby and Happey[4] and is being reported

elsewhere. It is sufficient at this stage to point out that, in the β-polypeptides, each amino-acid residue is associated with two inter-chain hydrogen bonds. Thus the presence of similar hydrogen bonds in the pellicle of the β-protein phase may well be one of the reasons for the unreactive nature of the wool fibre, especially if, in the bulk of the α-protein, the hydrogen-bonding is mainly intra-chain in character[5].

Thirdly, the behaviour of the protein molecule is very reminiscent of that of the copolymer of DL-β-phenylalanine plus glutamic γ-methyl ester. In this latter case[3], the solvent/polymer interaction appears to determine the form in which the molecule re-crystallized from solution, that is, β from formic acid and α from metacresol. In the case of the soluble wool product, however, the α-form can be obtained by precipitation from formic acid with water; but as this protein is highly swollen in weak formic acid, this is not surprising. Where, however, the formic acid concentration is retained during precipitation, the protein is regenerated in the β-form.

In conclusion, it is of interest to note that in these experiments the soluble keratin molecules appear to crystallize on precipitation from solution in the α-form. This result seems to be in conformity with the work of Mercer[6] on the regeneration of wool from solution, but the description of his method of preparation of the soluble wool curd is not sufficiently detailed to allow of a more exhaustive comparison of the two results at this stage. Whether the folded form is due to the dispersion of aggregates of unchanged α-protein molecules being reprecipitated, or whether during precipitation from weakly alkaline solution the high acidity of the side chains favours the formation of intra-chain hydrogen bonds in single molecules, is clearly a matter of importance in the general theory of protein structure. From the work of Bamford *et al.*[4], however, on the structure of polypeptides, it is becoming increasingly obvious that the configuration of the α-fold may well be influenced by the environment of the protein molecule in solution, a possibility which I envisaged in an earlier publication[7]. Added to this there is the additional evidence of the α- and β-forms which can be prepared from formic acid solution. It is reasonable to suggest, therefore, in this case, that the solvent/protein interaction may influence the final structure of the molecule. Further work on these lines is being carried out and will be reported in due course.

I wish to thank the directors of Courtaulds, Ltd., for permission to publish this communication.

[April 25.

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MAUI THE DEMI-GOD

FROM time immemorial adventure stories have taken hold of the imagination, and this is partly why the cult of Maui-of-a-thousand-tricks is so widespread in the Pacific*. The origin of this hero is not unparalleled in other mythologies: born of human parents, he was brought up by the gods and learnt their magic, so that when he returned to earth he was able to use this knowledge in part to aid humanity, in part for his own diversion and pranks. After his return to his parents—to the great relief, it is said, of the gods, who were wearied by his precocious artfulness—he used his knowledge of magic to bring to earth all kinds of benefits hitherto enjoyed only by the gods: firm dry land, clear sky and cooling winds, daylight sufficient for cultivation and fishing and fire to cook with. For all these things he lives in the memory of the people; but he is not worshipped, for he was but man.

The cult of Maui, though predominantly Polynesian, is found also in Micronesia and Melanesia, principally where there has been contact with Polynesia. In some islands there is a long story cycle, in others merely a footprint, or the legend that he fished up the island from the deep. The legends naturally vary from island to island; there can be no 'true' account of this hero, but the fact remains that he won the hearts of the islanders over a vast region and maintained that hold for centuries. He was the hero of no particular class; the common men and women loved him, and even the priests had to recognize him as a wonder-worker. There are more biographies of Maui than he was reputed to have heads (the eight heads with which some legends credit him really symbolize his versatility).

Perhaps the best-known version of the Maui legend is that given by Sir George Grey, governor of New Zealand in the early 1880's, which is related in full in the Bulletin of the Bernice P. Bishop Museum under notice. Story-telling being such a feature of Polynesian life, it is not surprising that the Maui myth has increased and multiplied, fostered by the schools for priests or for those becoming specialists in literature in various islands. The myths also inspire experts in string figures who show in successive figures the sequence of Maui's hectic career. Here, one might mention that a string figure series was collected in 1914 from the Kiwi Papuans of the Fly River delta[1], representing Maui first as a young man and finally showing his two children, a pig and a dog (both introduced into the island by man). This figure illustrates a folk tale collected from the same source by Landtman[2], thus showing that the Maui myth has an even wider distribution than is indicated in the present work.

In plays and puppet shows, also, Maui appears, and he is a strong influence in poetry. The Maui myths vary considerably both in content and style, according to the locality and even to the character of the people relating them. In the Society Islands the myths have even become incorporated into the religious cosmogony, although in New Zealand they are almost universally regarded as non-sacred. Among the marginal islands, Melanesian influence is felt, with its preoccupation with monsters and good and bad heroes, the Maui myth being modified to cover these predilections.

Katharine Luomala is to be congratulated on her perseverance in collecting this vast amount of material and for the diligence with which she has set her results on paper; the fact that the bibliography runs into more than three hundred items speaks for itself, and there is a full index.

K. RISHBETH

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Nuclear Shell Structure and Nuclear Density

THE existence of the shell structure of nuclei has been derived from a considerable variety of empirical facts (stability and abundance of nuclei, spin, magnetic moment, quadrupole moment, isomerism and β-decay)[1]. The closed shells of neutrons as well as of protons correspond to the numbers 2, 8, 20, 28, 50, 82, 126. Several theories[2] have been put forward, based on the model of a single nucleon moving in an average field of the rest. As it is not easy to conceive how a single particle embedded in matter of nuclear density could move in its own orbit without being disturbed by the others, we have searched for a more general explanation*. This is obtained with the help of a well-known relation first derived by Fermi, connecting the density $\rho(r)$ of a degenerate system of spin-half particles to the numbers of particles with angular momentum quantum number l. If one assumes that the formation of a closed shell is associated with the filling up of states of definite angular momentum, it follows that the closed shells are characterized by

$$[r^3\rho(r)]_{\max} = (2l+1)^3/24\pi^2.$$

Then calculations performed by the junior author show that the number of particles $N(l)$ in the l-th shell is

$$N(l) = f.(2l+3)^2,$$

where f is a quantity depending on the form of the density function $\rho(r)$. One sees that the difference of the cubic roots of successive shells $\Delta(N^{1/3})$ is a constant; namely, $2f^{1/3}$. Now this is at once empirically confirmed by the shell numbers in heavy nuclei, as shown in the following table:

$N(l)$	=	28	50	82	126
$\{N(l)\}^{1/3}$	=	3·04	3·69	4·35	5·01
$\Delta(N^{1/3})$	=		0·65	0·66	0·66

One can now calculate theoretically the shell numbers for different density distributions. The free Fermi-gas distribution gives too small a value of $\Delta(N^{1/3})$, equal to 0·52 instead of 0·66. However, a reasonable density distribution $\rho(r)$, constant in the interior and falling off like a Gaussian function near the border, namely,

$$\left.\begin{aligned}\rho(r) &= \rho_0 && \text{for } r \leqslant R_0\\ &= \rho_0 \exp\left\{-\left(\frac{r-R_0}{a}\right)^2\right\} && \text{for } r > R_0\end{aligned}\right\} \quad (1)$$

gives excellent result for $l \geqslant 3$. The constants ρ_0, a and R_0, determined uniquely by the empirical relation $\Delta(N^{1/3}) = 0{\cdot}66$, are

$$\left.\begin{aligned}\rho_0 &= 1{\cdot}04\Big/\frac{4\pi}{3}r_0^3,\\ a &= 0{\cdot}327\ r_0\ A^{1/3},\\ R_0 &= 0{\cdot}673\ r_0\ A^{1/3}.\end{aligned}\right\} \quad (2)$$

where r_0 is of the order of $1{\cdot}5 \times 10^{-13}$ cm.

The shell numbers $N(l)$ as calculated from (1) and (2) are tabulated in the following table:

l	=	3	4	5	6
$N(l)$	=	27·1	49·5	81·5	125·2
Next integer	=	28	50	82	126

For light nuclei, the central part of constant density no longer exists. When a purely Gaussian function is adopted for the nuclear density,

$$\rho(r) = \rho_0 \exp\left\{-\left(\frac{r}{a}\right)^2\right\}, \text{ with } \rho_0 = 0{\cdot}752\Big/\frac{4\pi}{3}r_1^3, \text{ and}$$

$$a = r_1 A^{1/3},$$

where r_1 is also of the order of $1{\cdot}5 \times 10^{-13}$ cm.

We again obtain correctly the first three shell numbers:

l	=	0	1	2
$N(l)$	=	1·55	7·16	19·66
Next integer	=	2	8	20

There must exist, of course, an intermediate region, presumably between 20 and 28, in which the transition takes place. Theoretical calculation of the nuclear density according to Dirac and Jensen's refinement of the Thomas–Fermi model of nuclei is now in preparation.

Thus the shell structure, owing to its correlation with the nuclear density, throws light on the possible form of the latter. In particular, it turns out that the thickness of the surface layer, instead of being constant and of the order of the nuclear-force range, has to be proportional to $A^{1/3}$. We further infer that the existence of a central part of almost constant density is due to the effect of the Coulomb repulsion, without which the nuclear density would be nearly Gaussian for all nuclei.

Detailed calculation will be published elsewhere by the junior author.

* *Note added in proof.* After having finished this paper, we found that the problem has been tackled in a similar way by Iwanenko and Polyjew[3], but with less success; the reason being that only ordinary forces of the Yukawa type are taken into account while actually exchange forces are predominant.

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May 18.

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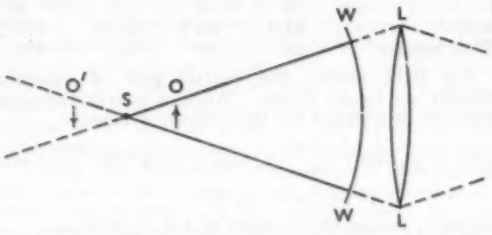
Microscopy by Reconstructed Wave-fronts

THE principle of Dr. D. Gabor's interesting method of reconstructing images of objects from photographs of the interference patterns produced when the object is illuminated with a coherent monochromatic wave-train is fully explained in his paper[1]. The treatment in this note is essentially the same, but I have ventured to present it in a very simplified form because I have found in discussions that difficulty is sometimes experienced in forming a physical picture of the reconstruction of the image, when the photographic plate can only record intensities of light and not phases.

The object O is placed close to a point source of light S. The wavelets scattered by the object interfere with the main waves from S over a surface such



as WW, altering both their amplitude and their phase. It is an essential condition for the success of the method that the amplitude due to the scattered waves should be small compared to that of the main waves. A photographic plate, which for simplicity we may suppose to coincide with a main wave surface such as WW, records the intensity of the resultant light at each point. The photograph is developed and printed as a diapositive. The pattern is quite unlike the object, being nearer to its Fraunhofer diffraction pattern than to a 'shadow'. Gabor then shows that if the diapositive is placed at WW, and the light is reversed, for example, by a lens LL focusing a beam at S, an image of O is reconstructed free from diffraction effects within, of course, the usual limits imposed by aperture and wave-length. Alternatively, the source S may be retained, and an eyepiece focused through the diapositive, when the image will be seen at the position of O. This result appears paradoxical because the photographic plate has only recorded intensities, whereas the formation of the image would seem to require that both amplitude and phase should be correctly reproduced.

The reason for the success of the method, and at the same time its limitations, can at once be seen if we picture wavelets scattered simultaneously by O and a corresponding object O' related to O by a centre of symmetry at S. The resultant of the wavelets from corresponding points at O and O' will have, by symmetry, a phase of 0 or π in relation to the main wave over the surface WW. Since this latter has a much larger amplitude, the total resultant phase is the same over WW and the only variation is in amplitude; complete information about this variation is recorded by the photographic plate.

When, therefore, the light is reversed through the diapositive, its wave form is that which would have been produced by S, O and O' (this is not strictly accurate, but very close to the truth when the secondary waves are small compared to the main wave, as will be seen by comparing the vector diagrams of amplitudes from S, O, O' and S, O alone), and all three images must be reproduced. As Dr. Gabor has shown, this is just what is observed when the experiment is tried. By altering the focus of the eyepiece, one sees at first O in focus against a bright background, then the source S, and finally the reversed image O' on the far side of S. We cannot see O without at the same time seeing a diffuse image O' out of focus behind it; this is the price paid for being unable to record phases. If, however, O is an object such as a narrow opaque line on a transparent background, the ideal case for the Gabor method, the image O' is almost invisible when out of focus. The method fails when O has large opaque areas, as these do not disappear when out of focus.

The principle of the method is identical with one familiar in X-ray analysis of crystals. Diffracted intensities are alone recorded, whereas to form a Fourier representation of the crystal structure one needs to know both amplitudes and phases. In certain favourable cases of centro-symmetrical projections there are atoms of such high atomic numbers at the cell-corners that all phases are zero, the other atoms merely altering the amplitude (for example, J. M. Robertson's analysis of platinum phthalocyanine[2]). The Fourier series can then be formed. The heavy atom corresponds to the source S, and the remaining atoms to O and O' in Gabor's method.

An even closer analogy is provided by the analysis of cholesteryl iodide by C. H. Carlisle and D. Crowfoot[3]. The crystal has no centre of symmetry. If the Fourier series is summed with phases appropriate to the heavy iodine atoms alone, it is equivalent to assuming a centre of symmetry and so phases of 0 or π. The Fourier series, therefore, shows both the actual molecule in the cell and its reversed image, corresponding to O and O' in Gabor's reconstruction.

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Delayed Particles in Extensive Air Showers

An attempt has been made, using two different experimental arrangements, to detect delayed particles in extensive air showers. In the first experiment (carried out under a thick concrete roof at University College, Dublin) extensive showers were selected by coincidences of three trays of Geiger–Müller counters, each tray of area 750 cm.^{2}. The trays were placed at the apices of a triangle of sides 5·3, 7·3 and 8·5 metres. Pulses from a fourth tray of area 360 cm.^{2} occurring 1·4–11·4 μsec. later were recorded.

In the second experiment showers were selected by two trays (A and B) each of area 1,500 cm.^{2}, horizontally separated by 2 m. Counts from a third tray, C, also of area 1,500 cm.^{2}, which occurred 1·5–6·5 μsec. afterwards, were recorded. Undelayed coincidences A, B, C were also recorded. In the first part of this experiment, tray C was unshielded; later, it was shielded by 20 cm. of carbon, and finally, with its area reduced to 600 cm.^{2}, it was shielded by 20 cm. of lead. This second experiment was per-

Arrangement	Rate of 3-fold undelayed coincidences per hr.	Time	No. of delayed events	Rate of delayed events per hr.	Expected rate of spurious delayed events per hr.
1st experiment	2·8± 0·08	375 hr.	0	0	0·001
2nd experiment C unshielded; area = 1,500 cm.^{2}	45±4	3 hr.	0	0	0·14
C shielded by 20 cm. of carbon; area = 1,500 cm.^{2}	30±1	18 hr.	2	0·1 ± 0·07	0·14
C shielded by 20 cm. of lead; area = 600 cm.^{2}	1±0·14	50 hr.	2	0·04± 0·028	0·04

formed under a light roof. The results of both experiments are given in the accompanying table.

It will be seen that in all cases the expected rate of spurious event is equal to or greater than the rate of delayed events recorded. Thus, in these experiments no evidence was found under a variety of conditions for particles delayed by more than 1·5 μsec. in air showers. It is unlikely that the fraction of delayed particles, if they occur, is greater than 5 per cent in any case.

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Thixotropy and Electrical Behaviour

The dynamical methods commonly employed in rheological measurements for determining thixotropic changes in pastes and non-Newtonian fluids are inadequate owing to the superimposition of the shear and time effects. However, in a system comprising an electrically conductive disperse phase, the processes of deflocculation under shear and reflocculation to a more or less connected skeletal structure during subsequent rest can be followed by conductimetric methods. Thus, a paste of carbon black in non-polar mineral oil exhibits a degree of electrical conductivity at any given stage of its rheological history which is in conformity with its rigidity and its appearance under the microscope.

With deflocculating media such as the polymerized oils used in printing inks, the specific conductivity of the paste may approach the low value characteristic of the medium itself and show very little growth of conductivity on prolonged ageing. In general, good printing inks comprising electrically conducting high-grade carbon blacks exhibit such low conductivities after shear that these are not measurable even with a condenser and ballistic galvanometer, small readings only being possible after a rest of several days. Nevertheless, the rigidities of such materials as determined with a delicate form of parallel-plate plastometer increase threefold and mobilities decrease more than fivefold during this period of rest after shear. When diluted with aromatic hydrocarbons, they form permanent colloidal sols of carbon black, which makes it evident that such dispersions comprise unlinked, independent and hence deflocculated particles. There is then in these latter systems a type of rheological thixotropy which is not based on a change of spatial arrangement of solid dispersate, and further investigation is needed to determine whether or not the underlying mechanism is due to a sol-gel transformation of the quasi-liquid interstitial layers.

In the absence of dipolar constituents in the medium forming a normally flocculated system, there is no evidence of cataphoresis after deflocculation by shear; nevertheless, maintenance of E.M.F. during the rest period greatly accelerates the growth of conductivity. The appearance of the material under the microscope when in an electric field confirms the latter observation; a 'lines-of-force' structure between the electrodes resembles in appearance iron filings in a magnetic field.

It has been claimed that a change of dielectric constant, based on capacitance measurements of thixotropic materials, has been observed under the respective conditions of shear and rest. While the determination of pure capacitance of non-conductive systems offers no difficulties, the results are misleading when there is ohmic conductance, and indeed measurement becomes nearly impossible when conductance grows during the observations. Systems comprising media and powders which exhibit virtually no conductivity, for example, dispersions of zinc oxide, rutile titanic oxide, etc., in liquid paraffin, show capacitances differing little from that of the pure medium, and although showing little or no drift of readings with time after thorough shear, may yet exhibit high rigidities and be, moreover, markedly thixotropic. The non-conductive printing ink systems referred to show very little increase of capacitance during their period of thixotropic regain of rigidity; indeed, this increase is often only recognizable by development of a slight loss of sensitivity of the recording instrument ('electric eye'). Hence it would appear that the large changes in 'capacitance' that have been recorded as evidence of thixotropy should rather be regarded as changes in the impedance of the system.

Work is proceeding on the quantitative aspect of these conductivity measurements.

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Departure from the Rayleigh Law of the Magnetization of a Ferromagnetic Material

Experiments have recently been carried out on the discontinuous changes in magnetization, as shown by the Barkhausen effect, in iron and nickel in the region where the Rayleigh law,

$$I = aH + bH^2,$$

holds. A very small number of Barkhausen discontinuities, so few as not to be reproducible, appeared in this region, followed by a sudden rapid increase in the number at the point where the law ceased to be obeyed. Results on a specimen of annealed iron, where the Rayleigh law ceases to hold for an applied field of about 0·38 oersted, illustrate this. As the applied field increased from zero up to 0·36 oersted, the number of discontinuities observed varied from 21 to 114: between 0·36 and 0·40 oersted the number lay between the limits 247 and 274.

It was noted that, for an applied field of ± 0·38 oersted, the hysteresis energy loss was 1·60 ergs/c.c./cycle, showing that irreversible changes in magnetization must have taken place in the Rayleigh 'region' despite the fact that so few Barkhausen discontinuities were observed. A further interesting point was that in the Rayleigh region some discontinuities were observed in the opposite sense to that expected, indicating a *decrease* in magnetization.

The magnetic characteristics of the materials used are shown in the accompanying table, where H_c is the coercive field, H' the field at which the Rayleigh law ceases to hold, and W_H the hysteresis energy-loss for limits of applied field $\pm H'$.

Néel[1] has given an explanation of the Rayleigh law in terms of small movements of the domain

Material	H_0 (oersted)	a	b	H' (oersted)	W_H (ergs/c.c./cycle)
Iron (annealed)	1·05	15·5	19·5	0·38	1·60
Iron (hard drawn)	6·8	6·5	1·45	2·2	21·5
Nickel (annealed)	1·2	9·8	39·5	0·32	2·0
Nickel (unannealed)	10·5	1·2	0·050	4·3	10·5

boundary walls due to the action of the magnetizing field, the wall energy depending on irregular perturbations in the magneto-crystalline energy. He has shown that there are reversible movements of the wall leading to a reversible magnetization, aH, and irreversible movements giving elementary hysteresis loops, the magnetization changing by $\pm bH^2$.

The energy perturbations have been attributed to magnetostrictive strains, or strains due to inclusions of foreign atoms, or both, and various workers[3,4,5] have used these ideas to explain the mechanism of the coercive field, this field having a value such that the domain wall is just able to move past the largest energy 'obstacle' it encounters as it changes its position.

An explanation, in the framework of these theories, of the effects described above is as follows.

In the Rayleigh 'region' the irreversible wall movements, which are small, give the irreversible magnetization and hence the Barkhausen discontinuities. These, however, are in general too small to be detected with the apparatus used[6]. As soon as the field reaches a value such that the domain wall can pass by the largest 'obstacle' in its path, it will move a comparatively large distance, and there will be a discontinuous increase in magnetization larger than is indicated by the Rayleigh law. In a polycrystalline material, this will take place when the 'critical' value of the applied field has been reached in any of the domains into which a particular crystal grain is divided. The magnetization increases more rapidly than the law predicts, and an appreciable number of Barkhausen discontinuities, large enough to detect, are observed. The coercive field will be a mean value of all the 'critical' fields involved. The values of the 'critical' fields will depend on the particular energy variations in the domains and on the orientation of the crystal axes of the various grains. The coercive field will thus be larger than the *minimum* value of the 'critical' field, indicated by H', the value of the magnetizing field at which departure from the Rayleigh law occurs (see table).

H', therefore, indicates a region where there is a transition from the small irreversible changes in magnetization in the Rayleigh 'region', to larger irreversible changes due to the action of the 'critical' field in the manner outlined above.

These investigations are being extended, and it is hoped to publish a detailed account of them in due course.

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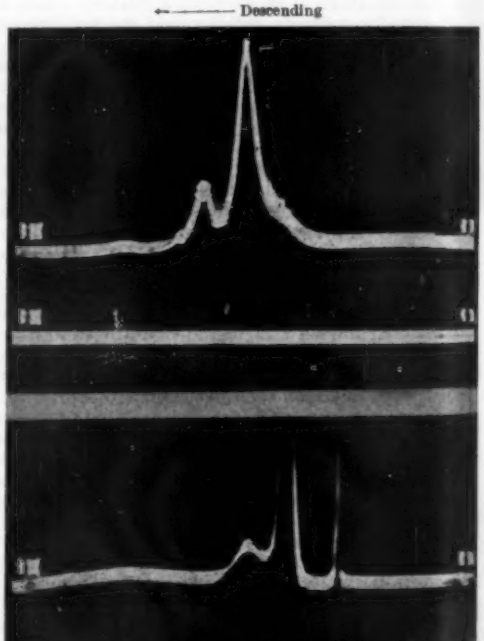
Reference Wedge for *Schlieren* Diagrams

One necessity for the quantitative analysis of *Schlieren* diagrams, as obtained by the Theorell–Philpot–Svensson cylindrical lens method[1], or the Longsworth *Schlieren* scanning method[2], is the precise definition of the base-lines. Although it is common practice to photograph a base-line obtained through a by-pass simultaneously with the pattern, details near the base-line may easily be covered up, and furthermore an uncertainty in the position of the base-line may be introduced, since the patterns of base-lines obtained from two different places in the plane of the cell cannot be expected to appear in exactly the same position. Another accepted technique consists in superimposing the base-lines taken through the channels of the cell at the beginning of the run upon the tracings of the final patterns, so that those parts which do not show an elevation coincide. It is, however, a frequent occurrence, in electrophoresis experiments, for example, that a pattern spreads out to such an extent that no part of it can be considered to indicate the position of the true base-line. The device described here permits analysis in cases such as this, while in all others it provides a useful check.

A glass wedge is mounted beside the channel (diffusion or adsorption analysis), or between the two channels (electrophoresis), and light from the linear light source is allowed to pass through this wedge by two rectangular holes near the ends of the channel. The width of each hole is about half that of the channel. The length is arbitrary and was about 4 mm. in the present arrangement. The wedge has two optically flat surfaces facing the lamp



and the camera, and the angle between them is such that the light is deflected downward and an image of the linear light source is produced at the diagonal slit about 5 mm. below that obtained through the channels. For example, if the distance between cell and diagonal slit is 2 m., the angle of the wedge is 17′. Two short sections of a displaced base-line appear beside the base-line of the pattern, as shown in the photograph. The displacement of 5 mm. is convenient for the usual changes in refractive index, such as are given by protein concentrations of 1–3 gm./100 ml., when a cell depth of 25 mm. is used. It is also well adapted for small changes in refractive index when very shallow slit angles are necessary.

The device is primarily designed for use with a slit in front of the camera; but it is also suitable for a bar or knife edge, if the exposure times are such that the parts of the photographic plate which receive light through both the channel of the cell and the wedge are not over-exposed.

The accompanying reproduction shows the ascending and descending electrophoretic patterns of a muscle protein extract which was electrolysed for a considerable length of time at high salt concentration. Note that the δ- and ε-boundaries have spread beyond the optical field. Correct superposition of the base-lines was achieved with the guidance of the reference-lines, which were made to coincide.

In order to obtain points of reference along the vertical direction, which are necessary for the determination of migration velocities from photographic records, horizontal wires are placed across the rectangular slits of the wedge mount. They appear in the photograph as vertical lines across the reference base-lines. The illumination on both sides of such lines is equal, and so their positions are not shifted by varying exposure or development times.

I wish to thank Prof. W. R. Amberson for facilities for experiment and for permission to publish two of his diagrams, and Miss Carolyn Stout for discussion and assistance. I am also indebted to the authorities of the London Hospital Medical College for granting me leave of absence. The wedge was made by, and may be obtained from, the Baltimore Instrument Company, Baltimore, Maryland, U.S.A.

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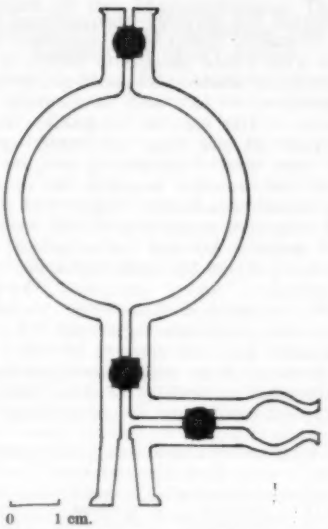
Pipetting Device for use with Radioactive Solutions

In a German army field laboratory apparatus, we have found a pipetting device for use with noxious liquids which should prove a more efficient means of handling radioactive solutions than the branched pipettes described by Swallow[1] and Gardner[2].

The device consists of a hollow rubber ball (5 cm. diameter) with two rubber tubes at opposite poles, each tube being closed with a valve. One tube is tapered internally to grip pipettes of different sizes; attached to this tube, between the valve and the tapered part, is a side-arm which also contains a valve and which has a dilatation to grip the expanded end of a gas-trap. X-ray photography has shown



that these valves consist of a glass ball contained within a regularly shaped cavity, and the valves remain air-tight until flats over the glass ball are squeezed with the fingers. The suction obtainable is sufficient to fill a 25-ml. pipette; by appropriate movements of the valves a larger pipette can be filled. Delivery is permitted by opening the valve of the side-arm, and the control of flow of the liquid is better than with the usual method of using pipettes. All operations can be performed with one hand.

Unfortunately, the maker is unknown and the apparatus has not been listed in any British catalogue which has come to our notice.

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Synthesis and Breakdown of Citric Acid with Crystalline Condensing Enzyme

The synthesis of citric acid from acetate, adenosine triphosphate and oxalacetate by soluble enzyme preparations from pigeon liver has been previously reported[1]. The system requires magnesium ions (Mg^{++}) or manganese ions (Mn^{++}) and coenzyme *A* as co-factors. Novelli and Lipmann[2] reported synthesis of citrate in *E. coli* extracts with acetyl phosphate and oxalacetate as substrates. We find that, in this case, at least two enzymes are required (cf. also ref. 3). The first enzyme, (*a*), activates acetyl phosphate; the second, (*b*), catalyses the condensation of 'active' acetate and oxalacetate to citrate. The overall reaction is: acetyl phosphate + oxalacetate = citrate + orthophosphate. Enzyme (*a*) can be obtained from various bacteria (*E. coli*, *Cl. butylicum*, *C. fœcalis*) practically free from (*b*). The condensing enzyme (*b*), which is readily soluble, is present in a variety of animal tissues (heart, skeletal muscle, liver, kidney, brain), bacteria (*E. coli*, *Azotobacter agilis*, *M. tuberculosis*) and yeast[4].

This enzyme has recently been isolated from pig heart in crystalline form[5] by a procedure involving extraction with dilute phosphate buffer, adsorption and elution from calcium phosphate gel, precipitation with ethanol at − 15°, and ammonium sulphate fractionation. The enzyme crystallizes as slender needles from 50 per cent saturated ammonium sulphate. One unit of condensing enzyme has been defined as the amount required to catalyse the synthesis of one micromole of citric acid in 10 min. at 25° in a system containing *E. coli* extract (as a source of enzyme (*a*) and coenzyme *A*) and the following components (in micromoles per ml. of reaction mixture): acetyl phosphate, 10·5; oxalacetate, 20; magnesium chloride, 4; L-cysteine, 10; and potassium phosphate buffer *p*H 7·4, 25. The initial extracts have an activity of 0·6–1 unit per mgm. of protein. After several recrystallizations the final product has an activity of about 330 units per mgm. Typical results are shown in Table 1.

Table 1. Activity of Twice Recrystallized Condensing Enzyme

Enzyme (mgm.)	Acetyl phosphate* removed (micromoles)	Citrate synthesis (micromoles)	Specific activity of enzyme (units/mgm.)
0·0041	1·3	1·36	332
0·0082	2·6	2·70	329
0·0123	4·1	4·13	336
0·0164	5·3	5·21	318

* Determined as hydroxamic acid (ref. 6).

Enzyme (*a*) is probably identical with Stadtman's transacetylase[7], which catalyses an interchange of acetyl-bound phosphate with inorganic phosphate in the presence of coenzyme *A*. The condensing enzyme catalyses a slow exchange of acetyl-bound oxalacetate (that is, oxalacetate bound as citrate) with free oxalacetate in the presence of coenzyme *A*. This indicates that the reaction catalysed by this enzyme is reversible, but its equilibrium is far toward citrate synthesis. As shown in Table 2, the oxalacetate exchange is obtained only when small amounts of the keto acid are present, and is markedly inhibited when the oxalacetate concentration is increased. This is probably due to competition between oxalacetate and citrate for an active site on the enzyme.

Table 2. Enzymatic Exchange between Citrate and Oxalacetate containing Carbon-14

Additions			Counts in oxalacetate per minute	
Coenzyme *A* (units)	Condensing enzyme (units)	Oxalacetate (micromoles)	*β*-Carboxyl	Carboxyl of residual pyruvate
20	100	40	22	
20	100	10	47	
20	100	2	135	92
20	0	2	26	
0	100	2	3	
20	80	2	114	103

1·0 ml. of reaction mixture containing (in micromoles) phosphate buffer *p*H 7·0, 50; magnesium chloride, 4; L-cysteine, 10; carbon-14 labelled sodium citrate, 20 (31,200 counts per minute); with other additions as indicated, incubated 5 hr. at 25°. Carrier oxalacetate was then added to all samples (except in exp. 1) to make 20 micromoles. The oxalacetate (*β*-carboxyl) was decarboxylated by heat and the residual pyruvate with yeast carboxylase. The carbon dioxide was collected in alkali and counted as barium carbonate. The condensing enzyme used in the last experiment was twice recrystallized (specific activity 330); the other experiments were conducted with an amorphous fraction of specific activity 110. The radioactive citrate was prepared biosynthetically with *Aspergillus niger* fermenting glucose in the presence of carbon-14 dioxide (ref. 8). Enzymatic degradation of this citrate showed that almost all the radioactivity was present, and about equally distributed, in the two carboxyls of its oxalacetate moiety (730 counts/min./micromole in each carboxyl).

We are indebted to Mrs. Nora Howell and Mr. Tibor Farkas for assistance. The work was supported by grants from the United States Public Health Service, the American Cancer Society (recommended by the Committee on Growth of the National Research Council), the Office of Naval Research, and the Rockefeller Foundation.

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Alkaline Fission of some 2-Substituted Dimethyl-ethyl-sulphonium Iodides

In a paper published under this title, Crane and Rydon[1] described the behaviour towards alkali of some sulphonium iodides of the general structure, $R.CH_2.CH_2.\overset{+}{S}Me_2\}I^-$. Among such compounds those in which *R* was Ph.CO.O— and Ph.O— were remarkably labile, consuming alkali in the cold and decomposing on warming with alkali according to the equation:

$$R \cdot CH_2 \cdot CH_2 \cdot \overset{+}{S}Me_2\}I^- + 2NaOH \rightarrow R\text{Na} + CH : CH + SMe_2 + NaI + 2H_2O.$$

We have been engaged for some time in a further examination of the action of alkali on sulphonium iodides of the type $Ar.CO.O.CH_2.CH_2.\overset{+}{S}Me_2\}I^-$, and now find that the reaction proceeds in two distinct stages, thus:

(i) $$Ar \cdot CO \cdot O \cdot CH_2 \cdot CH_2 \cdot \overset{+}{S}Me_2\}I^- + NaOH \rightarrow Ar \cdot CO \cdot ONa + CH_2 : CH \cdot \overset{+}{S}Me_2\}I^- + H_2O.$$

(ii) $$CH_2 : CH \cdot \overset{+}{S}Me_2\}I^- + NaOH \rightarrow NaI + CH : CH + SMe_2 + H_2O,$$

of which only the first proceeds at a measurable speed at room temperature under mildly alkaline conditions (*p*H *c.* 10). Crane and Rydon[1] stated that both stages took place in the cold, no doubt owing to a misunderstanding arising from the circumstance that their work was written up for publication some years after it had been completed, under conditions of some urgency, as part of a war-time study of the mode of action of mustard gas. Accordingly, their theoretical interpretation of this reaction, and of the similar one undergone by $PhO.CH_2.CH_2.\overset{+}{S}Me_2\}I^-$, is invalid, although the remainder of their experimental work still stands.

We have studied the rather remarkable elimination reaction (i) with a series of substituted benzoyloxyethyl dimethyl sulphonium iodides, $X.C_6H_4.CO.O.CH_2.CH_2.\overset{+}{S}Me_2\}I^-$, by continuous titration with alkali in the apparatus of Powell and

Trendall[2]. The reaction is first-order with respect to both hydroxyl and sulphonium ion, and we have obtained the following bimolecular velocity constants for 0·005 *M* solutions of the various sulphonium iodides in water at 25°:

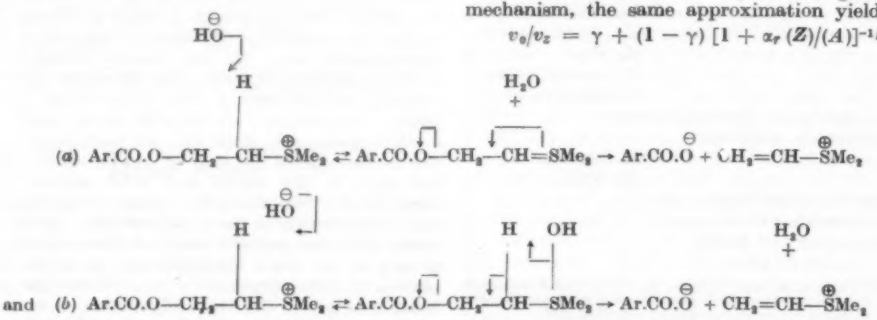
X	*p*-MeO	*o*-MeO	*p*-Me	*o*-Me	H	*p*-Cl	*o*-Cl	*o*-NO_2	*p*-NO_2
k_2(mol./litre/min.)	211	291	319	314	356	476	673	1242	1611

Clearly the reaction is facilitated by electron-attracting substituents *X*. There is no obvious indication of the operation of the ortho-effect, which is only what is to be expected if the hydroxyl ion attacks at or near the positively charged sulphur, which is far removed from the aromatic nucleus. The plot of log k_2 against Hammett's σ-values for *p*-substituents is as linear as usual ($\log_{10}k_2 = 2{\cdot}562 + 0{\cdot}825\,\sigma$), and the apparent absence of any ortho-effect emboldens us to deduce the following σ-values for *o*-substituents:

X	*o*-MeO	*o*-Me	*o*-Cl	*o*-NO_2
σ	− 0·120	− 0·080	+ 0·320	+ 0·645

These values are put forward with some reserve, since the reaction shows a negative salt effect which is greater than would be expected on the basis of the Brønsted equation[3]; they are, nevertheless, probably quite near to the truth.

The occurrence of this reaction cannot be ascribed solely to the presence of a positive pole, since it is not shown by the nitrogen analogue, $Ph.CO.O.CH_2.CH_2.\overset{+}{N}Me_3\}I^-$. This suggests that the neutral intermediate indicated by the negative salt effect may have a structure in which the sulphur carries an electron decet; such a structure is, of course, impossible for nitrogen but possible for phosphorus, and we hope to examine the phosphorus analogue. We find, too, that similar alkali-lability is shown by the sulphone, $Ph.CO.O.CH_2.CH_2.SO_2.Me$, but not by the sulphoxide, $Ph.CO.O.CH_2.CH_2.SO.Me$. Two possible mechanisms are:



Both these fit the available data, and we cannot at present distinguish between them. Our investigation is being continued and will be reported fully elsewhere in due course.

P. Mamalis

Birkbeck College,
London, E.C.4.

H. N. Rydon

Imperial College of Science and Technology,
London, S.W.7.

May 16.

[1] Crane and Rydon, *J. Chem. Soc.*, 766 (1947).
[2] Powell and Trendall, *Chem. and Indust.*, **62**, 368 (1943).
[3] cf. Olson and Simonson, *J. Chem. Phys.*, **17**, 1167 (1949).

Inhibition of the Homogeneous Thermal Decomposition of Acetaldehyde by Chemically Inert Gases

It is possible to make a classification of all the different types of mechanisms which correspond to a given order of the initial rate of the homogeneous gas phase thermal decomposition of simple organic compounds[1] if a free-radical chain mechanism is admitted. These types of mechanisms differ in two ways: (*a*) in the type of radicals which takes part in the chain-breaking step, which can be a bimolecular reaction or a triple collision; and (*b*) in the chain-initiating step, which can be monomolecular or bimolecular.

It would be expected that in any of these cases chemically inert gases could influence the reactions: acting as a partner in chain-breaking triple collisions, they can decrease its rate; or they can increase it by serving as an activating partner in chain-initiating bimolecular collisions. From the equations previously given[1], it is easy to show that if v_0 is the initial rate in a pure vapour at the concentration (A), and v_z in the presence of a concentration (Z) of an 'inert gas', the ratio v_0/v_z depends on (1) (Z) only, if, in the absence of *Z*, chain-initiation is monomolecular and chain-breaking bimolecular; (2) $(Z)/(A)$ only, if, in the absence of *Z*, chain-initiation is bimolecular and chain-breaking termolecular; (3) (Z) as well as on $(Z)/(A)$, if, in the absence of *Z*, chain-initiation is bimolecular and chain-breaking bimolecular (or monomolecular and termolecular).

Although the exact relationship between v_0/v_z and (A) and (Z) is complicated, a reasonable approximation gives, for case 2:

$$(v_0/v_z)^2 = [1 + \alpha_r(Z)/(A)]/[1 + \alpha_i(Z)/(A)], \quad (1)$$

where α_r and α_i are the relative collision efficiencies of *Z* compared to *A* in chain-breaking or chain-initiating steps.

If a fraction γ is decomposed according to a molecular mechanism, and $1 - \gamma$ according to a chain mechanism, the same approximation yields:

$$v_0/v_z = \gamma + (1 - \gamma)\,[1 + \alpha_r\,(Z)/(A)]^{-1/2}. \quad (2)$$

For acetaldehyde, M. Letort[2] had shown that v_0 is of the order $n = 3/2$. This result has been confirmed recently[3], and there is no reason for believing that the measured kinetics is influenced by minute traces of oxygen or peroxides[4], since samples, of which proportions between 30 and 70 per cent had been decomposed in previous runs, decompose at exactly the same rate as fresh, thoroughly purified samples.

We have now shown that chemically inert gases such as carbon dioxide, hydrogen and nitrogen decrease the initial rate, as had been shown already for carbon monoxide and mixtures of carbon monoxide and methanes by Letort[2]. The accelerating effect of hydrogen observed by various authors[5], and of carbon

dioxide observed by J. R. E. Smith[6], is probably attributable to the presence in those gases of traces of oxygen, which strongly accelerates the thermal decomposition of acetaldehyde[3,7].

The non-dependence of v_0/v_z on (Z), for constant $(Z)/(A)$ ratios, can be clearly demonstrated by experiment, and the results agree well with equation 1.

The calculated relative efficiencies are:

Z	Carbon dioxide	Carbon monoxide and methane	Hydrogen
α_i	very small	0·06	very small
α_r	0·20	0·33	0·41

These results of inhibition prove the existence of a chain mechanism. Although they do not exclude the possibility of a simultaneous molecular mechanism, they show that the proofs as yet given are insufficient, since equation 1 yields an 'inhibition limit' as well as equation 2.

On the other hand, relation (2) shows that these reactions are initiated by a bimolecular step and that the chain-breaking step is termolecular. There are data in the literature which suggest[8] that this is also the case for other reactions; but the application of conclusive tests would be desirable.

It should be noticed that the results of J. R. E. Smith and C. N. Hinshelwood[9] concerning the retarding effect of propylene on the pyrolysis of acetaldehyde can be expressed formally by the same relation (1) (with $\alpha_i = 7$ and $\alpha_r = 40$) as the retarding effect of carbon dioxide, carbon monoxide and methane. This formal analogy might be ascribed to the fact that a termolecular process of recombination of two free radicals R' and R'' is kinetically indistinguishable from the sequence of processes:

$$R' - + M \rightleftharpoons R' - M$$
$$R' - M + R'' \rightarrow R'R'' + M,$$

when the addition complex $R' - M$ has a sufficiently short life-time.

The considerations here presented will be developed later elsewhere (*Bull. Soc. Chim. Belg.*, in the press).

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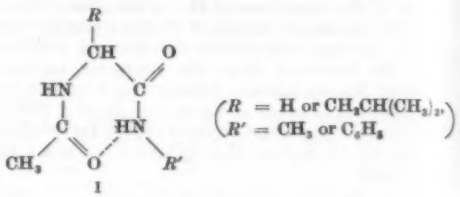
April 24.

[1] Goldfinger, P., Letort, M., and Niclause, M. (Victor Henri Memorial Volume, 283 (Liège, 1948)). Such a classification has been made for a molecule, which can be represented by a symbol *ABC*.
[2] Letort, M., *J. Chim. Phys.*, **34**, 267, 355, 428 (1937).
[3] Niclause, M., Goldfinger, P., and Letort, M., *C.R. Acad. Sci., Paris*, **229**, 437 (1949).
[4] Cf. Williams, Gwynn, and Singer, K., Ann. Rep. Chem. Soc., **45**, 52 (1948).
[5] Hinshelwood, C. N., and Askey, P. J., *Proc. Roy. Soc.*, A, **115**, 163 (1927). Fletcher, C. J. M., and Hinshelwood, C. N., *Trans. Farad. Soc.*, **30**, 614 (1934).
[6] Smith, J. R. E., *Trans. Farad. Soc.*, **35**, 1328 (1939).
[7] Niclause, M., and Letort, M., *C.R. Acad. Sci., Paris*, **226**, 77 (1948); *Rev. Inst. Fr. Pétrole*, **4**, 319 (1949).
[8] Kuechler, L., and Theile, H., *Z. Phys. Chem.*, **42** B, 359 (1939). Eltenton, G. C., *J. Chem. Phys.*, **15**, 454 (1947). Walters, W. D., *J. Amer. Chem. Soc.*, **62**, 880 (1940). Goldfinger, P., Faraday Soc. Discussion, **2**, 149 (1947). Partington, R. G., and Danby, C. I., *J. Chem. Soc.*, 226 (1948). Agius, P., and Maccoll, A., *J. Chem. Phys.*, **18**, 158 (1950). Szwarc, M., Faraday Soc. Discussion, **2**, 138 (1947).
[9] Smith, J. R. E., and Hinshelwood, C. N., *Proc. Roy. Soc.*, A, **180**, 237 (1942).

Near Infra-Red Spectra of Proteins and Related Substances

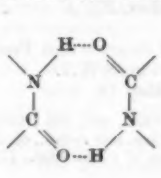
In addition to the extended configuration of a polypeptide chain, we have proposed a bent or folded configuration, and tried to explain the experimental data of proteins by the various combinations of these two basic configurations[1]. The experimental proof for the existence of the bent configuration of the molecule of acetylglycine anilide (I) afforded evidence



I

in support of our view[2]. The same results have since been obtained for acetylglycine N-methyl amide, acetylleucine anilide and acetylleucine N-methyl amide: namely, in very dilute carbon tetrachloride solutions, these substances exhibit two characteristic absorption peaks, one at 3,450 cm.$^{-1}$ arising from the NH-group in the free state, and the other at 3,330 $\sim$ 3,360 cm.$^{-1}$ from that involved in the intramolecular hydrogen bonding. (These experiments were carried out with Sugita, Kato and Kondo of this Laboratory and the details will be published elsewhere.)

According to our measurements, as well as those of other investigators[3,4], proteins exhibit two absorption peaks, at 3,290 $\sim$ 3,330 cm.$^{-1}$ and at 3,080 $\sim$ 3,090 cm.$^{-1}$, arising from the hydrogen-bonded NH-groups; salmin exhibits the third peak at 3,240 cm.$^{-1}$ arising from the side-chain. The fact that the dipeptides mentioned exhibit only one absorption peak arising from the hydrogen-bonded NH-group is due to the free state of their molecules in dilute solutions. Owing to the low solubility of these substances in carbon tetrachloride, we could not measure the absorptions in concentrated solutions where the state of hydrogen bonding is more akin to that of proteins. In compounds containing one peptide bond, such as N-methyl acetamide, however, we were able to carry out measurements not only in concentrated solutions, but also in the liquid and solid states, and we observed the two absorption peaks of practically the same frequencies as those of proteins. It should be noted that the peptide bond of these compounds is always in the *trans* configuration, as is the case in protein models proposed by us[5]. When the peptide bond is nearly in the *cis* configuration, as in the case of δ-valerolactam, ε-caprolactam, diketopiperazine, etc., the absorption peaks are observed at 3,210 $\sim$ 3,240 cm.$^{-1}$ and at 3,070 $\sim$ 3,100 cm.$^{-1}$. Therefore, the peptide bonds in the main chain of polypeptide cannot be considered to be in the *cis* configuration, and the hydrogen bond of the type shown would not be formed between two main chains of polypeptides.



Darmond and Sutherland also measured the NH-frequencies of compounds containing peptide bonds, but arrived at a conclusion different from ours[3]. They consider that the 3,280 cm.$^{-1}$ band arises from a structure different from that to which they assigned the 3,060 cm.$^{-1}$ band. However, as stated above, such two bands can arise from a single structure in the case of N-methyl acetamide, δ-valerolactam and ε-caprolactam in solutions, and acetanilide and diketopiperazine in the solid state. The proof that each of these substances has a single molecular configuration which is associated in a single way is given by the measurement of the Raman effect, infra-red absorption or dipole moment (N-methyl acetamide, δ-valerolactam and ε-caprolactam)[5], and by X-ray diffraction experiments (acetanilide[6] and diketopiperazine[7]). For the dimer of carboxylic acids, it is also known that more than one O—H vibration arises from a single structure[8]. Therefore, the appearance of more than one NH-stretching frequency cannot be used as a proof of the existence of more than one type of hydrogen bond, and the objection of Darmond and Sutherland to the structure of α-keratin proposed by us[1] and independently by Ambrose *et al.*[9] is not supported by our infra-red measurements.

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Takehiko Shimanouchi
Masamichi Tsuboi

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March 11.

[1] Shimanouchi, T., and Mizushima, S., *Kagaku*, **17**, 24 (1947); *Bull. Chem. Soc. Japan*, **21**, 1 (1948). See also *Chem. Abst.*, **43**, 8843 (1949).
[2] Mizushima, S., Shimanouchi, T., Tsuboi, M., Sugita, T., and Kato, E., *Nature*, **164**, 918 (1949).
[3] Darmon, S. E., and Sutherland, G. B. B. M., *Nature*, **164**, 440 (1949); *J. Amer. Chem. Soc.*, **69**, 2074 (1949).
[4] Buswell, A. M., Krebs, K. F., and Rodebush, W. H., *J. Phys. Chem.*, **44**, 1126 (1940). Klotz, I. M., Griswold, P., and Gruen, D. M., *J. Amer. Chem. Soc.*, **71**, 1615 (1949).
[5] Mizushima, S., Shimanouchi, T., Nagakura, S., Kuratani, K., Tsuboi, M., Baba, H., and Fujioka, O., *J. Amer. Chem. Soc.* (accepted for publication).
[6] Brown, C. J., and Corbridge, D. E., *Nature*, **162**, 72 (1948).
[7] Corey, R. B., *J. Amer. Chem. Soc.*, **60**, 1598 (1938).
[8] Buswell, A. M., Rodebush, W. H., and Roy, M. F., *J. Amer. Chem. Soc.*, **60**, 2239 (1938).
[9] Ambrose, E. J., and Hanby, W. E., *Nature*, **163**, 483 (1949). Ambrose, E. J., Elliot, A., and Temple, R. S., *ibid.*, **163**, 859 (1949).

Locus of the Gene 'Fidget' in the House Mouse

In an attempt to place 'fidget' (symbol *fi*), described by Grüneberg[1], on the chromosome map of the house mouse, *Mus musculus*, a multiple test-cross has been made recently in this Department.

There is now adequate evidence that the locus of this gene is linked with that of Danforth's 'short tail' (symbol *Sd*). Coupling back-cross data give a recombination value of about 25 per cent, the χ^2 on independent segregation being more than 50 for one degree of freedom. Owing to the poor viability of the genotype *Sd* + *fi*/*fi*, this member of the cross-over class is slightly deficient, and the recombination value may, in fact, be somewhat higher. Due to this cause also, there has been some delay in making up repulsion back-crosses. These, however, will shortly be available. Full data on the linkage so far indicated will be given as soon as balanced coupling and repulsion data have been produced.

The linkage of *Sd* and *fi* extends the mapped portion of chromosome V. Carter and Grüneberg[2] report a loose linkage of 'fidget' and the 'agouti' locus, of which the latter is already mapped on chromosome V. Data on *Sd* and 'agouti', available in this Department, give evidence of a looser linkage, about 40 per cent recombination; this has been further corroborated by news of D. Kelton's work at Bar Harbor. The order appears, then, to be *Sd*—*fi*—*A*. Work is now in progress in this Department to determine the exact linkage relations between these three loci and those already mapped on this chromosome.

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University of Cambridge.

May 13.

[1] Grüneberg, H., *J. Genet.*, **45**, 22 (1943).
[2] *Heredity* (in the press).

Fertilization of the Rat Egg

The use of the phase-contrast microscope for the study of certain stages in the fertilization of rat eggs has been described[1]. It was pointed out that pressing the eggs beneath a coverslip greatly improved the visibility of the internal structure. More recently, it has been found that, if the Fallopian tubes are dissected under liquid paraffin and the eggs transferred to a slide with some of the fluid which surrounds them while in the Fallopian tube, they would survive for several hours even when pressed beneath a coverslip. During this period the changes involved in fertilization proceeded in an apparently normal manner, and could readily be observed and photographed.

The time of survival differed with individual eggs and also with the degree of pressure to which they were subjected, but was usually not less than six to eight hours or more than twelve to sixteen hours. Within limits, the more the eggs are compressed the greater is visibility improved; but survival, and the occurrence of certain of the changes, are apt to be interfered with if the vertical thickness of the vitellus is reduced to less than about 15 μ. The optimal thickness seems to be about 20 μ.

Under the conditions described, it has been possible to observe in detail, and to photograph, the occurrence *in vitro* of the following complete series of changes: (*a*) the detachment of the sperm head and the conversion of its substance, with the exception of the apical cap or acrosome, into the male pronucleus; the acrosome remains unchanged and is recognizable in eggs recovered at later stages; (*b*) the changes in the second maturation spindle consequent upon sperm penetration as far as the formation of the female pronucleus; (*c*) part of the growing phase of the pronuclei; (*d*) the sequence of events from the conjugation of the pronuclei to the formation of the two-cell nuclei; as yet, however, the actual division of the cytoplasm to form a two-cell egg has not been found to occur under the conditions employed.

These observations and photographic records, together with data on the time relations of the stages of fertilization *in vivo* as well as *in vitro*, are being prepared for publication.

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Glebe, N.S.W.

April 27.

[1] Austin and Smiles, *J. Micr. Soc.*, **68**, 13 (1948).

FORTHCOMING EVENT

Monday, September 4

Association for the Study of Animal Behaviour (at the Royal Society of Tropical Medicine, 26 Portland Place, London, W.1), at 5 p.m.—Prof. Karl von Frisch: "Methods of Communication in the Honey Bee".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHEMISTS in the Ministry of Supply Chemical Inspectorate, primarily for analysis of materials associated with atomic energy production, including radio-active materials, and development and application of up-to-date physico-chemical techniques and equipments—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.486/50A (September 9).

LECTURER (honours graduate with good qualifications in physical chemistry) IN CHEMISTRY, up to Special Degree standard—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham (September 9).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING (Electronics)—The Registrar, The University, Liverpool (September 9).

LECTURER IN RADIO COMMUNICATION—The Secretary, South-East London Technical College, Lewisham Way, London, S.E.4 (September 9).

SENIOR ASSISTANT IN THE ELECTRICAL ENGINEERING AND PHYSICS DEPARTMENT—The Secretary, Poplar Technical College, Poplar High Street, London, E.14 (September 9).

SENIOR ASSISTANTS IN THE DEPARTMENTS OF MECHANICAL AND CIVIL ENGINEERING at the Bradford Technical College—The Director of Education, Town Hall, Bradford (September 9).

ASSISTANTS IN EXPERIMENTAL AND THEORETICAL PHYSICS—The Secretary, The University, Aberdeen (September 10).

SCIENTISTS, Grade III (with a good honours degree in chemistry, preferably with some experience of, or special interest in, investigational work on chemical analysis, in the Board's Coal Survey Laboratories at Newcastle-upon-Tyne—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/244 (September 11).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in engineering or an equivalent qualification) in the Royal Naval Scientific Service—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3233 (September 12).

ASSISTANT LECTURER or LECTURER IN GENERAL BACTERIOLOGY IN THE DEPARTMENT OF BOTANY—The Registrar, University College, Cathays Park, Cardiff (September 16).

ELECTRONIC ENGINEERS and PHYSICISTS (Experimental Officer grade) at Ministry of Supply Research and Development Establishments in the South Midlands—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.253/50A (September 16).

LECTURERS (with a degree in electrical engineering, or an equivalent qualification) at the R.E.M.E. Training Centre, Arborfield, under the War Department—The Under-Secretary of State, War Office (M.E.1), London, S.W.1 (September 16).

PHYSICISTS (Scientific Officer grade) (with a first- or second-class honours degree in physics and good general electronic knowledge and experience) at Ministry of Supply Research and Development Establishments near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.234/50 (September 16).

PILE CONTROL ENGINEERS (Engineer III), at the Atomic Energy Establishment, Harwell, for the operation of heavy nuclear energy plant, mainly of a mechanical nature, requiring some knowledge of instrumentation and control—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.444/50A (September 16).

SCIENTISTS (honours graduates with experience in medical or veterinary research) at a Ministry of Supply Research Establishment in South-West England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.231/50 (September 16).

CARTOGRAPHER (with a good honours degree in geography, mathematics, physics, engineering, or geology, or a kindred subject, or an equivalent qualification) in the Hydrographic Department of the Admiralty—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3265 (September 21).

LECTURER IN SHEEP HUSBANDRY in the New South Wales Department of Technical Education—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (September 28).

LECTURER IN GEOLOGY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

LECTURER or SENIOR LECTURER IN FLUID DYNAMICS at the University and Hobart Technical College, Tasmania—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 30).

LECTURER IN ECONOMICS at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 13).

LECTURER IN PHYSICS at Rhodes University College, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

AGRONOMISTS (with a degree in agriculture), an ENTOMOLOGIST (with a degree in science, including entomology as a major subject), and a BIOCHEMIST (with a specialized honours degree in chemistry and post-graduate experience in biochemistry, particularly plant biochemistry)—The Secretary, Tobacco Research Board of Southern Rhodesia, P.O. Box 1909, Salisbury, Southern Rhodesia.

ANALYST (preferably experienced in the analysis of non-ferrous metals and alloys)—The Research Manager, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

BURSARY for fundamental research on the physical chemistry of reactions of importance in iron and steel making, tenable with the Nuffield Research Group in Extraction Metallurgy at the Imperial College of Science and Technology—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

DEMONSTRATOR IN BOTANY, with special qualifications in bacteriology—The Registrar, The University, Nottingham.

FIELD OFFICERS by the East African High Commission for the Desert Locust Survey, to organize locust destruction work in desert and semi-desert areas in East Africa and Arabia—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M/N/26874/3A.

INSTRUMENT ENGINEERS (with a good honours degree in mechanical or electrical engineering or physics), by the Division of Atomic Energy (Production), Capenhurst Factory, Chester, to be responsible for the maintenance of physical and electronic instruments used in chemical process control—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

MEDICAL ENTOMOLOGIST (male), for duties in connexion with field investigation into the entomological aspects of communicable diseases, in H.M. Colonial Service, Uganda—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27215/45.

REGIONAL TRIALS OFFICER (with a university degree or diploma in agriculture and/or biology and previous experience of conducting field trials)—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Report on the Work of the Tin Research Institute, 1949. Pp. 16. (Greenford: Tin Research Institute, 1950.) [67

Philosophical Transactions of the Royal Society of London, Series A: Mathematical and Physical Sciences. No. 852, Vol. 242: A Purification Method for Computing the Latent Columns of Numerical Matrices and some Integrals of Differential Equations. By L. F. Richardson. Pp. 439–491. 12s. No. 853, Vol. 242: The Levels in the North Sea associated with the Storm Disturbances of 8 January 1949. By R. H. Corkan. Pp. 493–525. 7s. 6d. (London: Cambridge University Press, 1950.) [77

Hannah Dairy Research Institute. Bulletin No. 9: The Effects of Temperature, Humidity, Air Movement and Solar Radiation on the Behaviour and Physiology of Cattle and other Farm Animals: a Review of Existing Knowledge. By Dr. J. D. Findlay. Pp. 178. (Kirkhill: Hannah Dairy Research Institute, 1950.) 6s. net. [107

Hungarian Christianity in the New Hungarian State. By Bishop Bereczky. Pp. 16. (Birmingham: 'Religion and the People', 1950.) 6d. [107

Other Countries

Philosophia Naturalis. Band 1, Heft 1. Pp. 176. (Meisenheim am Glan: Verlag Anton Hain, 1950.) [77

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Dominion Museum Records in Entomology. Vol. 1, No. 8: A Revision of the New Zealand Wetas—*Anostostominae* (Orthoptera: Stenopelmatidae.) By Dr. J. T. Salmon. Pp. 57. (Wellington: Dominion Museum, 1950.) [77

Indian Forest Records, New Series. Wood Technology, Vol. 1, No. 2: The Formation of Growth Rings in Indian Trees, Part 5, A Study of some Discs of Sandalwood (*Santalum album*). By K. Ahmad Chowdhury and S. S. Ghosh. Pp. iii+16–27+2 plates. (Delhi: Manager of Publications, 1950.) 2 rupees; 3s. [107

Annual Report of the Indian Central Jute Committee for the Year 1948–49. Pp. ii+171. (Calcutta: Indian Central Jute Committee, 1949.) [107

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Annual Report of the All-India Institute of Hygiene and Public Health, Calcutta, 1947–48. Pp. vii+59+4 plates. Annual Report of the All-India Institute of Hygiene and Public Health, Calcutta, 1946–47. Pp. v+45+2 plates. (Calcutta: Government of India Press, 1949–1950.) [107

Catalogues

Wild-Barfield Vertical Muffles. Pp. 2. (Watford: Wild-Barfield Electric Furnaces, Ltd., 1950.)

Books on various Subjects, including Archaeology, History and Economics, Early Printing, Art, Scotland. (Catalogue 705). Pp. 90. (London: Francis Edwards, Ltd., 1950.)

G.E.C. Journal. Vol. 17, No. 3, July. Pp. 105–156. (London: General Electric Co., Ltd., 1950.)

Variable Air Capacitors, Types A–411, D–14 and A–430. (Bulletin B.653.A.) Pp. 8. Decade Capacitors. (Bulletin B.654.A). Pp. 4. 'Universal' Capacitance Units, Types B–22 and B–516. (Bulletin B.655.A). Pp. 2. Standard Mica Capacitors. (Bulletin B.656.A). Pp. 4. Filter Capacitors, Types M–70 and M–80, Mica, Type 233–AT, Paper. (Bulletin B.657.A). Pp. 2. Inductors. (Bulletin B.658.A). Pp. 4. (Beckenham: Muirhead and Co., Ltd., 1950.)